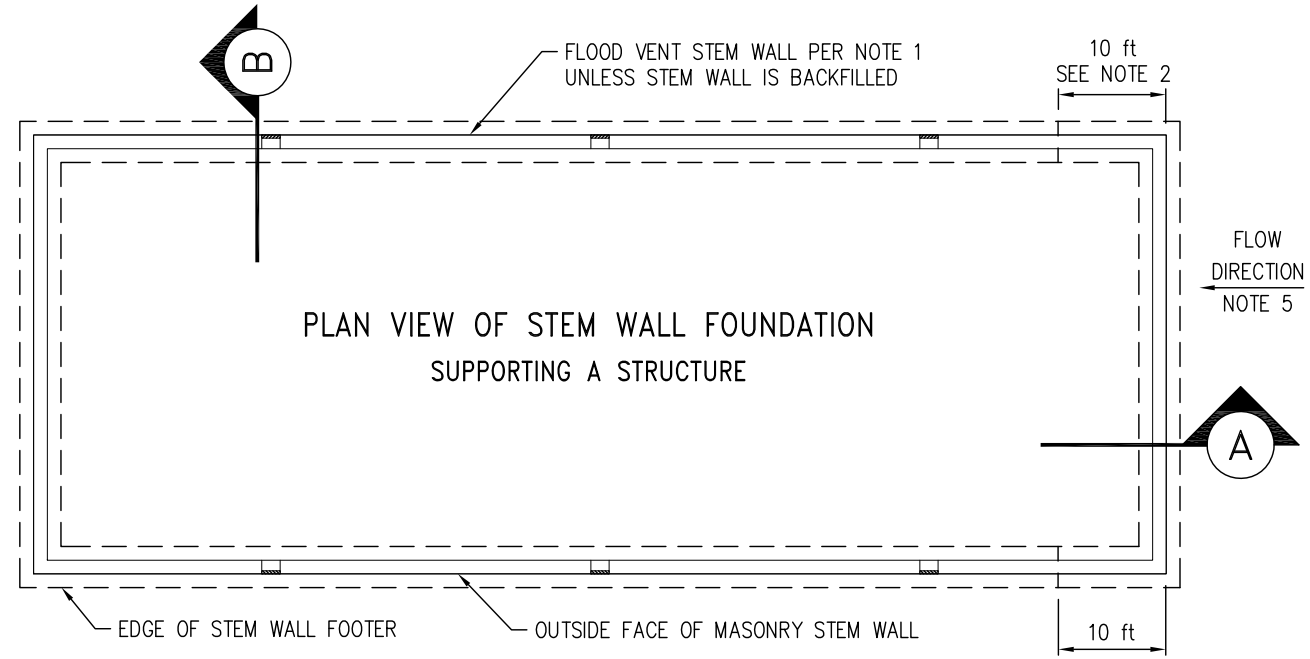
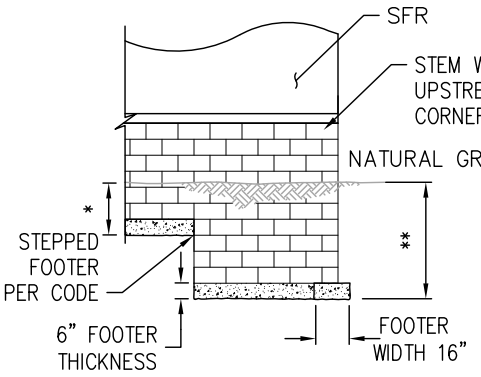
NOTES

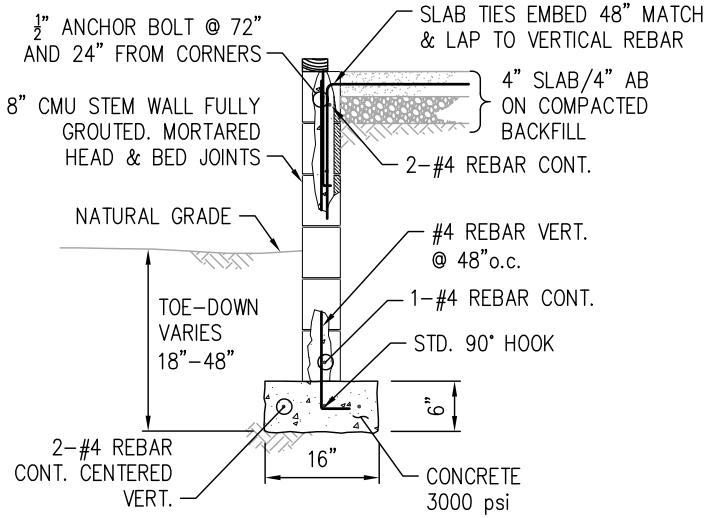
1. VENT OPENINGS IN STEM WALL:
   - PROVIDE 1 SQUARE INCH OF NET OPEN VENT AREA FOR EACH SQUARE FOOT OF BUILDING FLOOR SPACE
   - PLACE BOTTOM OF VENTS 1 FOOT (MAX) ABOVE NATURAL GRADE.
   - ALL SCREENS AND LOUVERS MUST AUTOMATICALLY OPEN TO ALLOW UNOBSTRUCTED FLOW OF FLOOD WATERS, OR OTHERWISE MAY BE SCREENED WITH ½–INCH MIN SCREEN.
   - DISTRIBUTE REQUIRED VENTS UNIFORMLY ON AT LEAST TWO OPPOSING WALLS.
2. FOOTER DEPTH FROM TABLE 014–B, SHALL APPLY ALONG ENTIRE UPSTREAM END, AND ALONG UPSTREAM–MOST 10 FEET OF BOTH SIDES OF STEM WALL. FOOTER DEPTH FOR REMAINING STEM WALL FROM TABLE 014–C.
3. FOR MONOPOUR FOUNDATIONS, POUR FOUNDATION DOWN TO DEPTH FROM TABLE 014B–C AND 014–C.
4. FOUNDATION ELEMENTS LOCATED WITHIN THE PERIMETER OF STEM WALL SHALL NOT BE REQUIRED TO BE PLACED BELOW MAXIMUM ANTICIPATED SCOUR DEPTH. LOCATION OF, AND STRUCTURAL CHARACTERISTICS OF INTERIOR FOUNDATION ELEMENTS SHALL BE DETERMINED BY OTHERS.
5. STRUCTURAL FOOTER CHARACTERISTICS SUCH AS WIDTH, THICKNESS, REINFORCING, ETC. ARE MINIMUM ALLOWED AND ARE SUBJECT TO BUILDING CODE REVIEW.
6. LONG DIMENSION OF STRUCTURE TO BE ORIENTED PARALLEL TO DIRECTION OF FLOW.
7. MATERIALS: CONCRETE 3000 psi; MORTAR TYPE M, N, OR S PER ASTM C270; GROUT SHALL BE COARSE AGGREGATE PER ASTM VC476; REBAR 60 KSI; CMU ASTM C–90 TYPE I OR TYPE II.





* TOE–DOWN DEPTH FROM TABLE 014–C
** TOE–DOWN DEPTH FROM TABLE 014–B

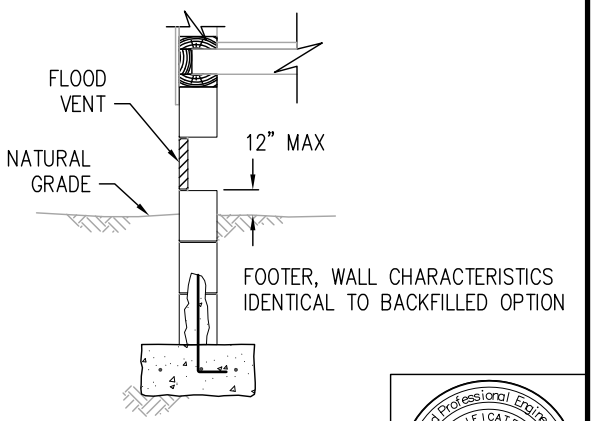
A SECTION
SCALE: N.T.S.



B SECTION BACKFILLED
SCALE: N.T.S.

ABBREVIATIONS:

SEE FIGURE 014–B OR 014–C



B SECTION VENTED
SCALE: N.T.S.

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PIMA COUNTY
FLOOD CONTROL

FIGURE 014–A
EROSION PROTECTION OF LOAD BEARING PERIMETER STEM WALL IN FLOODWAY FRINGE AREAS

SCALE: None | DRAWN BY: sak | DATE: Aug. 2019

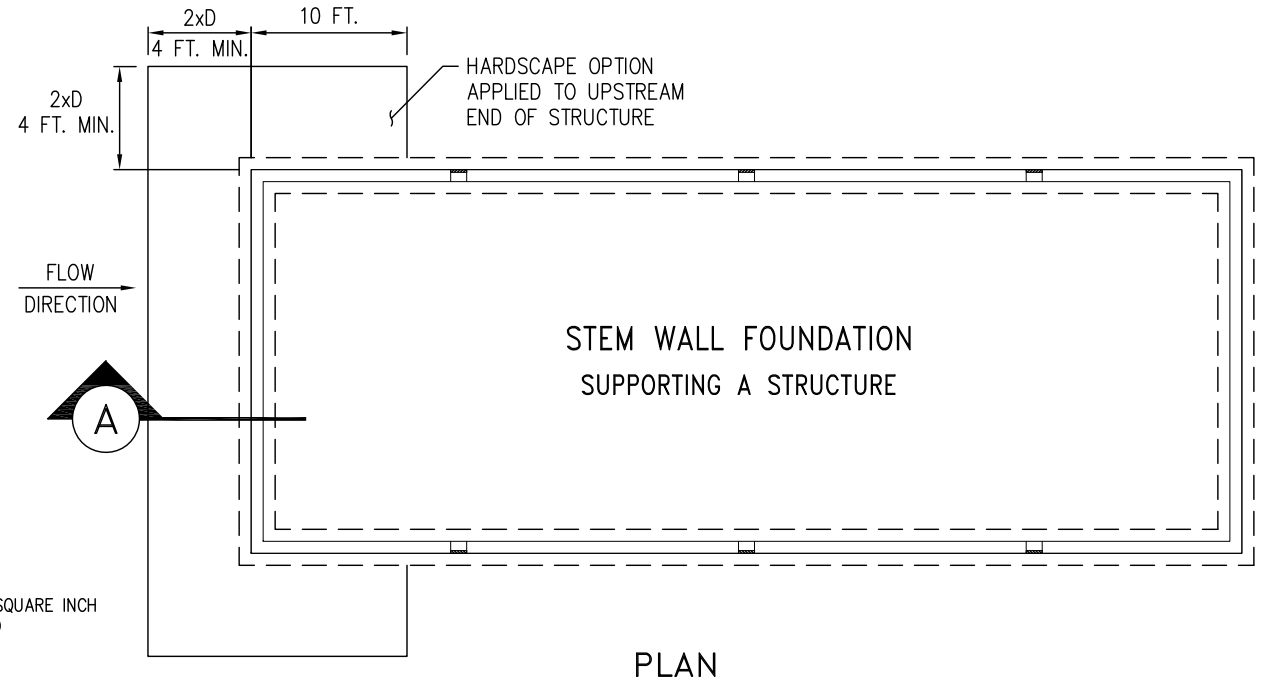
THE SEAL of PIMA COUNTY ARIZONA

NOTES

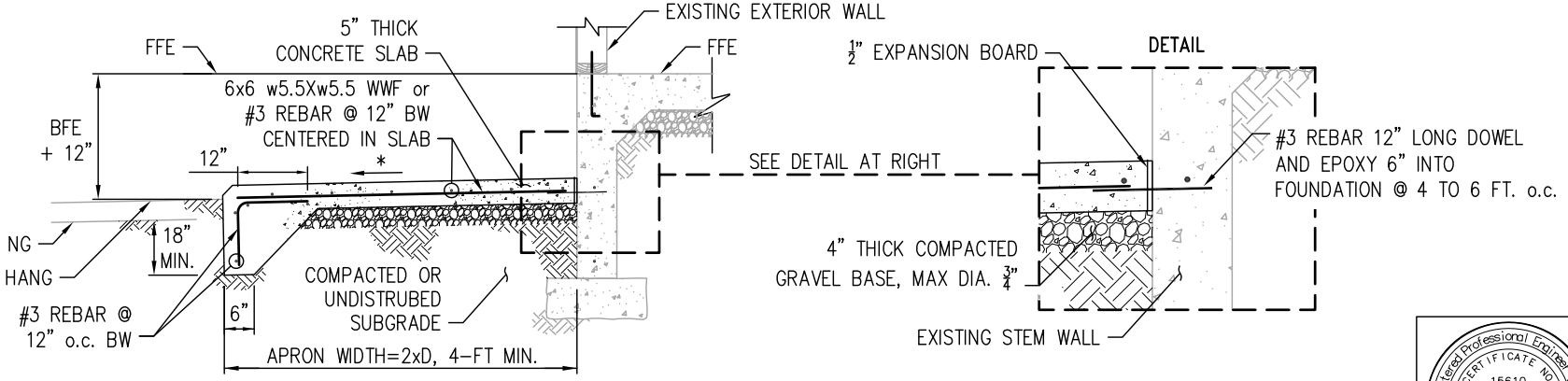
1. GRAVEL BASE AND SUBGRADE COMPACTED TO 95% STANDARD PROCTOR DENSITY.
2. VERIFY THAT HOLES FOR DOWEL BAR ARE CLEAN AND DRY PRIOR TO PLACING BONDING MATERIAL.
3. SHIFT DOWEL HOLE LOCATIONS IF EXISTING REINFORCING STEEL IS ENCOUNTERED.
4. PLACE SCORED EXPANSION JOINTS $\frac{1}{4}$ INCH DEEP EVERY 6 FEET OF LENGTH.
5. THIS OPTION FOR FOUNDATION EROSION PROTECTION MAY NOT BE USED WITH POST-STRESSED FOUNDATION DESIGN.
6. MATERIALS: CONCRETE 3000 PSI, REBAR 60 ksi, GRAVEL BASE PC/DOT SSPI SECTION 303.
7. TOE-DOWN FROM TABLE 014-B.
8. LONG DIMENSION OF STRUCTURE TO BE PARALLEL TO FLOW.
9. STRUCTURAL FOUNDATION CHARACTARISTICS (WIDTH, DEPTH, THICKNESS, REBAR) SUBJECT TO BUILDING CODE REVIEW.

ABBREVIATIONS

BW	= BOTH WAYS	ksi	= KILOPOUND PER SQUARE INCH
BFE	= BASE FLOOD ELEVATION	NG	= NATURAL GROUND
CMU	= CONCRETE MASONRY UNIT	N.T.S.	= NOT TO SCALE
D	= TOE-DOWN DEPTH	o.c	= ON CENTER
d	= DEPTH OF EXISTING FOOTER	SSPI	= PC/DOT STANDARD SPECIFICATIONS for PUBLIC IMPROVEMENT
FFE	= FINISH FLOOR ELEVATION	WWF	= WELDED WIRE FABRIC
HANG	= HIGHEST ADJACENT NATURAL GRADE		



PLAN
SCALE: N.T.S.



A HARDSCAPE OPTION
SCALE: N.T.S.

* SLOPE: $\frac{1}{8}$" TO $\frac{1}{4}$" PER FT.

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PIMA COUNTY
FLOOD CONTROL

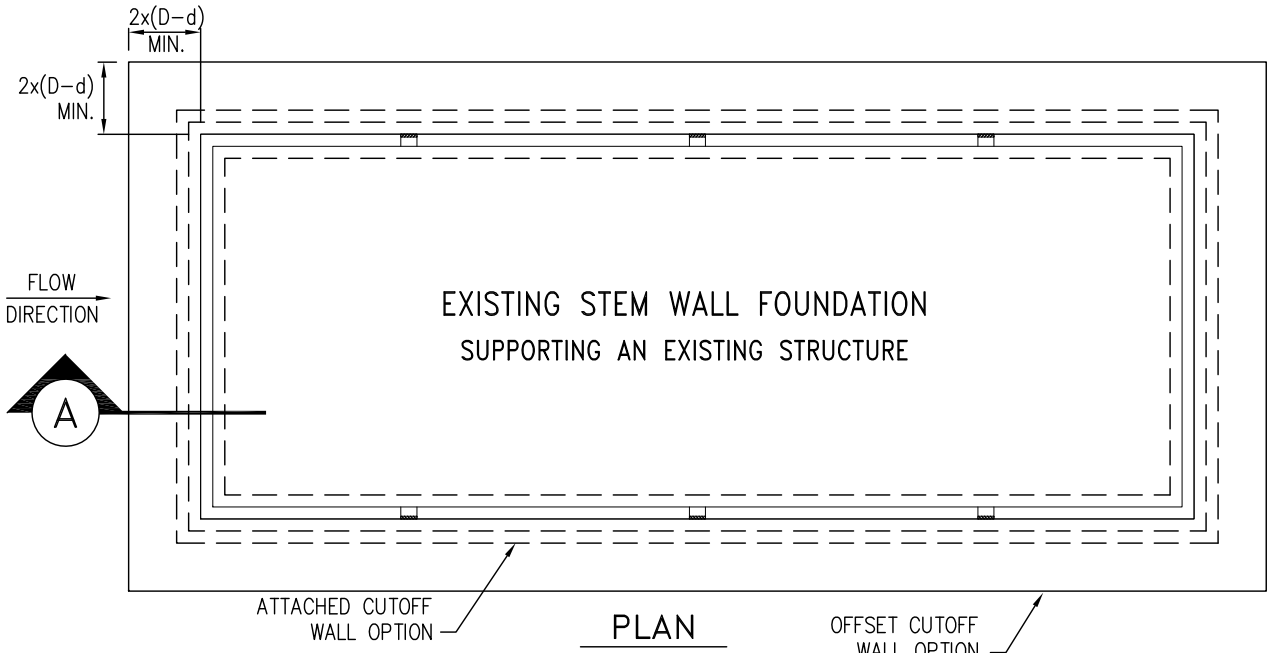
FIGURE 014-B
HARDSCAPE OPTION FOR EROSION PROTECTION FROM ABUTMENT SCOUR OF LOAD BEARING PERIMETER STEM WALL IN FLOODWAY FRINGE AREAS

SCALE: None | DRAWN BY: sak | DATE: July 2019

THE SEAL of PIMA COUNTY ARIZONA

NOTES

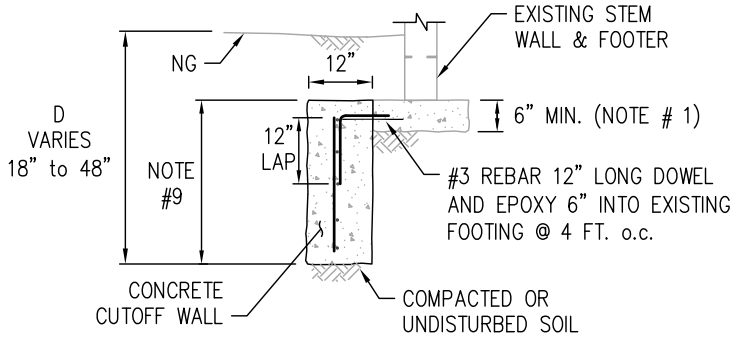
1. FOR ATTACHED CUTOFF WALL OPTION, THICKNESS OF EXISTING FOOTING MUST BE 6" MIN. AND TOP OF FOOTER MUST BE WITHIN 12" OF SURFACE.
2. VERIFY THAT HOLES FOR DOWEL BARS ARE CLEAN AND DRY PRIOR TO PLACING EPOXY.
3. SHIFT DOWEL HOLE LOCATIONS IF EXISTING REINFORCING STEEL IS ENCOUNTERED.
4. DRILL DOWEL HOLES IN EXISTING FOUNDATION PRIOR TO EXCAVATION OF TRENCH BELOW BOTTOM OF FOOTER.
5. MATERIALS: CONCRETE 3000 PSI, REBAR 60 ksi, GRAVEL BASE SSPI SECTION 303.
6. REBAR, WWF TO BE CENTERED IN SLAB AND/OR CUTOFF WALL.
7. 6x6 W5.5xW5.5 WWF OR #3 REBAR @ 12" o.c. BW.
8. #3 REBAR @ 6" o.c. OR #4 @ REBAR 12" o.c. BW, TYP.
9. CUTOFF WALL HEIGHT AS NECESSARY TO ACHIEVE SCOUR DEPTH.
10. TOE-DOWN FROM TABLES 014-B & 014-C.



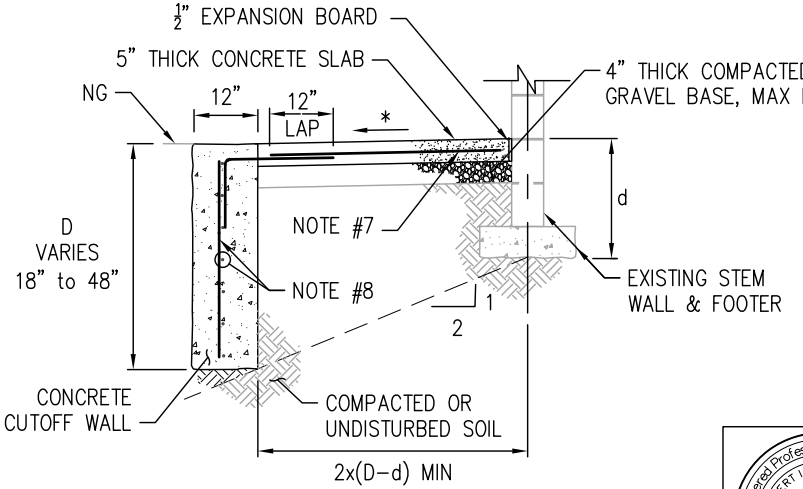
PLAN
SCALE: N.T.S.

ABBREVIATIONS

BW	= BOTH WAYS	ksi	= KILOPOUND PER SQUARE INCH
BFE	= BASE FLOOD ELEVATION	NG	= NATURAL GROUND
CMU	= CONCRETE MASONRY UNIT	N.T.S.	= NOT TO SCALE
D	= TOE-DOWN DEPTH	o.c	= ON CENTER
d	= DEPTH OF EXISTING FOOTER	SSPI	= PC/COT STANDARD SPECIFICATIONS for PUBLIC IMPROVEMENT
FFE	= FINISH FLOOR ELEVATION		
HANG	= HIGHEST ADJACENT NATURAL GRADE	WWF	= WELDED WIRE FABRIC



A ATTACHED CUTOFF WALL OPTION
SCALE: N.T.S. APPLICATION LIMITED TO SITES WHERE TRENCH WALLS WILL STAND VERTICAL AND NOTE 1



A OFFSET CUTOFF WALL OPTION
SCALE: N.T.S.

* SLOPE: ⅛" TO ¼" PER FT.

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PIMA COUNTY
FLOOD CONTROL

FIGURE 014-C
RETRO FIT OPTION FOR EROSION PROTECTION OF LOAD BEARING PERIMETER STEM WALL IN FLOODWAY FRINGE AREAS

SCALE: None DRAWN BY: sak DATE: July 2019

THE SEAL of PIMA COUNTY ARIZONA

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO: Technical Policy, TECH-015 **EFFECTIVE DATE: October 1, 2007**
REVISION DATE: 5/18/21

POLICY NAME: Acceptable Methods for Determining Peak Discharges

PURPOSE

To standardize the selection of hydrologic models and other methods to be used to determine peak discharges.

BACKGROUND

When peak discharges need to be established or revised, a computer-based hydrologic model or previously-accepted discharge value may be used. Different hydrologic models may be appropriate for different applications. This policy describes when different hydrologic models should be used for submittals to the Pima County Regional Flood Control District (District), and what other methods of determining peak discharges are acceptable. Modeling protocols and accepted parameters are discussed in Technical Policies TECH 018 and TECH-033.

POLICY

A. Peak discharges may be computed as follows:

1. ***For non-distributary watersheds < 1 square mile with negligible detention or retention structures:*** The Pima County Hydrology Procedures (e.g., PC-HYDRO) should be used.

2. ***For non-distributary watersheds < 1 square mile with detention or retention structures:*** HEC-1 or HEC-HMS may be used.

3. ***For non-distributary watersheds > 1 square mile:*** HEC-1, HEC-HMS should be used.

4. ***For watersheds with distributary flow:*** Two dimensional modeling such as FLO-2D or HEC-RAS 2D should be used.

B. The use of other methods for determining peak discharge shall be as follows:

1. ***For watersheds where the District has conducted studies:*** The use of peak discharges from previously-approved Basin Management Studies (or other studies conducted for or by the District) is acceptable in lieu of hydrologic modeling. The District will review these discharges to make sure that methods do not conflict with

any current regulations and parameters, and methods are in conformance with sound and contemporary engineering practice.

2. ***For watersheds where previous studies have been accepted by the District:*** Peak discharges may be used from studies that have been previously accepted by the District (i.e., Drainage Reports). Peak discharges incorporated into new Drainage Reports submitted in support of development plans or plats shall be verified and certified as valid by the engineer of record. The District will review these discharges to ensure that methods do not conflict with any current regulations and parameters and methods are in conformance with sound and contemporary engineering practice.

3. ***Return-period analysis:*** If measured flow data are available, return-period analysis may be performed and analyzed using the methods described in the most-recent guidance provided by the United States Geological Survey (Bulletin 17C; England et al, 2019). The District will consider the uncertainty of the estimate for a given return period in determining whether to accept the value.

4. ***Regional Regression Analysis:*** In rare cases, the District may accept peak flood estimates from the most recent regression analysis by the United States Geological Survey (Paretti et al, 2014; Kennedy and Paretti, 2014). These methods can be valuable to evaluate reasonableness of peak discharges determined by hydrologic models. Application of the regional regression analysis is provided under Technical Policy 018.

5. ***Other Models:*** Approval of the use of other models, such as FLO-2D, shall be obtained in writing from the District prior to the submittal of the peak discharge analysis. A copy of the written permission must be included with the submittal.

6. ***FEMA Map Revisions:*** Hydrologic analyses must be supported by a numerical model meeting the minimum requirements of the National Flood Insurance Program (NFIP) requirements for flood hazard mapping activities, administered through the Federal Emergency Management Agency (FEMA).

REFERENCES

England, J.F., Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas, W.O., Jr., Veilleux, A.G., Kiang, J.E., and Mason, R.R., Jr., 2019, Guidelines for determining flood flow frequency—Bulletin 17C (ver. 1.1, May 2019): U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., https://doi.org/10.3133/tm4B5.

Kennedy, J.R., and Paretti, N.V., 2014, Evaluation of the magnitude and frequency of floods in urban watersheds in Phoenix and Tucson, Arizona: U.S. Geological Survey Scientific Investigations Report 2014–5121, 29 p., *http://dx.doi.org/10.3133/sir20145121*.

Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G., 2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., *http://dx.doi.org/10.3133/sir20145211*.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 10/1/2007
Date(s) Revised: 5/18/21

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO: Technical Policy, TECH-015 **EFFECTIVE DATE: October 1, 2007**
REVISION DATE: 5/18/21

POLICY NAME: Acceptable Methods for Determining Peak Discharges

PURPOSE

To standardize the selection of hydrologic models and other methods to be used to determine peak discharges.

BACKGROUND

When peak discharges need to be established or revised, a computer-based hydrologic model or previously-accepted discharge value may be used. Different hydrologic models may be appropriate for different applications. This policy describes when different hydrologic models ~~may or shall~~should be used for submittals to the Pima County Regional Flood Control District (District), and what other methods of determining peak discharges are acceptable. Modeling protocols and accepted parameters are ~~not~~ discussed in ~~the policy~~Technical Policies TECH 018 and TECH-033.

POLICY

A. Peak discharges may be computed as follows:

1. ***For non-distributary watersheds < 1 square mile with negligible detention or retention structures:*** The Pima County Hydrology Procedures (e.g., PC-HYDRO~~ydro~~) should~~all~~ be used.

2. ***For non-distributary watersheds < 1 square mile with detention or retention structures:*** HEC-1 or HEC-HMS may be used.

3. ***For non-distributary w~~W~~atersheds > 1 square mile ~~and < 10 square miles~~:*** HEC-1, HEC-HMS ~~(including Geo-HMS) or the Pima County Hydrology Procedures may be used. If the Pima County Hydrology Procedures are used, the Time of Concentration must be < 180 minutes and detention and retention must be negligible. HEC-1 or HMS (including Geo-HMS) is preferred~~should be used.

~~4. *For watersheds > 10 square miles:* HEC-1 or HEC-HMS (including Geo-HMS) shall be used.~~

~~5.~~4. ~~*For outlying watersheds:* Where watershed information is sparse or unknown, and the development impact on the floodplain is minimal (e.g., not subject to subdivision requirements, or to determine erosion hazard concerns), the USGS Regression~~

~~Equation 13 (Thomas et al, 1997) or Eychaner equations (Eychaner, 1984) may be used.~~***with distributary flow:*** Two dimensional modeling such as FLO-2D or HEC-RAS 2D should be used.

B. The use of other methods for determining peak discharge shall be as follows:

1. ***For watersheds where the District has conducted studies:*** The use of peak discharges from previously-approved Basin Management Studies (or other studies conducted for or by the District) is acceptable in lieu of hydrologic modeling. The District will review these discharges to make sure that methods do not conflict with any current regulations and parameters, and methods are in conformance with sound and contemporary engineering practice.

2. ***For watersheds where previous studies have been accepted by the District:*** Peak discharges may be used from studies that have been previously accepted by the District (i.e., Drainage Reports). Peak discharges incorporated into new Drainage Reports submitted in support of development plans or plats shall be verified and certified as valid by the engineer of record. The District will review these discharges to ensure that methods do not conflict with any current regulations and parameters and methods are in conformance with sound and contemporary engineering practice.

3. ***Return-period analysis:*** If measured flow data are available, return-period analysis may be performed and analyzed using the methods described in the most-recent guidance provided by the United States Geological Survey (Bulletin 17C; England et al, 2019). The District will consider the uncertainty of the estimate for a given return period in determining whether to accept the value.

4. ***Regional Regression Analysis:*** In rare cases, the District may accept peak flood estimates from the most recent regression analysis by the United States Geological Survey (Paretti et al, 2014; Kennedy and Paretti, 2014). These methods can be valuable to evaluate reasonableness of peak discharges determined by hydrologic models. Application of the regional regression analysis is provided under Technical Policy 018.

5. ***Other Models:*** Approval of the use of other models, such as FLO-2D, shall be obtained in writing from the District prior to the submittal of the peak discharge analysis. A copy of the written permission must be included with the submittal.

6. ***FEMA Map Revisions:*** Hydrologic analyses must be supported by a numerical model meeting the minimum requirements of the National Flood Insurance Program (NFIP) requirements for flood hazard mapping activities, administered through the Federal Emergency Management Agency (FEMA).

REFERENCES

England, J.F., Jr., Cohn, T.A., Faber, B.A., Stedinger, J.R., Thomas, W.O., Jr., Veilleux, A.G., Kiang, J.E., and Mason, R.R., Jr., 2019, Guidelines for determining flood flow frequency—Bulletin 17C (ver. 1.1, May 2019): U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p., https://doi.org/10.3133/tm4B5.

Kennedy, J.R., and Paretti, N.V., 2014, Evaluation of the magnitude and frequency of floods in urban watersheds in Phoenix and Tucson, Arizona: U.S. Geological Survey Scientific Investigations Report 2014–5121, 29 p., *http://dx.doi.org/10.3133/sir20145121*.

Paretti, N.V., Kennedy, J.R., Turney, L.A., and Veilleux, A.G., 2014, Methods for estimating magnitude and frequency of floods in Arizona, developed with unregulated and rural peak-flow data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2014-5211, 61 p., *http://dx.doi.org/10.3133/sir20145211*.

~~Eychaner, James H. 1984. *Estimation of Magnitude and Frequency of Floods in Pima County with Comparisons of Alternative Methods*. USGS Water Resources Investigations Report 84-4142, 69pp.~~

~~Thomas, B.E., Hjalmarson, H.W. and Waltemeyer, S.D. 1997. *Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States*. USGS Water Supply Paper 2433. 195pp~~

APPROVED BY:

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 10/1/2007
Date(s) Revised: 5/18/21

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO: Technical Policy, TECH-018 **EFFECTIVE DATE: November 16, 2012**
REVISION DATE: 5/18/21

POLICY NAME: Acceptable Model Parameterization for Determining Peak Discharges

PURPOSE

The purpose of this technical policy is to standardize the parameterization of hydrologic models for concentration points of interest within a **contributing-flow** regime. Policy regarding parameterization of hydrologic models within distributary-flow regimes is provided under Technical Policy *TECH-033, Criteria for Two-Dimensional Modeling*.

BACKGROUND

When determining peak discharges, a computer-based hydrologic model or previously-accepted discharge value may be used. Technical Policy *TECH-015, Hydrologic Model Selection for Peak Discharge Determination,* describes which models are acceptable for determining peak discharges. This policy describes which parameterization shall be used for submittals to the Pima County Regional Flood Control District (District).

POLICY

A. **Watershed Delineation:** The accuracy of watershed delineation and flow path identification is critical in hydrologic modeling. The watershed delineation shall leverage high-resolution topography that meets or exceeds the United States Geological Survey (USGS) 3-D Elevation Program standards (FEMA, 2018). In areas of steep terrain, or where high-resolution topography is not available, USGS contour maps (7.5 minute series) may be accepted. At the discretion of the District, it may be a requirement that topographic data be sealed by an Arizona registered civil engineer (PE), or land surveyor (RLS).

   For watershed delineation within regulatory sheetflood areas, or areas with potential distributary flow patterns, two-dimensional modeling may be required. Technical Policy *TECH-033, Criterial for Two-Dimensional Modeling* provides the criteria for watershed delineation when performing two-dimensional modeling.

B. **Pima County Hydrology Procedures:** Peak-discharge calculations performed using the Pima County Hydrology Procedures shall follow the guidance for parameterization provided in the PC-HYRDO User Guide (District, 2019).

C. **HEC-1 and HEC-HMS:** Peak discharges calculated using HEC-HMS (COE, 2018) or HEC-1 (COE, 1998) shall employ the following parameterization:

a. ***Rainfall Loss Method:*** Models shall employ the U.S Soil Conservation Service (SCS) Curve Number method using the Curve Number tables. Vegetation map and Hydrologic Soils Group map associated with the PC-HYDRO User Guide (District, 2019) shall be used. The default vegetation cover percent provided in the PC-HYDRO User Guide (District, 2019) shall be used unless additional justification is provided. The Curve Number shall not be adjusted for rainfall intensity or antecedent moisture conditions.

b. ***Time of Concentration Calculation:*** The modified U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (T_c) calculation shall be employed (USDA-NRCS, 1986). The Tc shall be calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow, along the primary flow path.

   i. For sheet flow segment:
      1. Manning's roughness coefficient for sheet flow shall be obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).
      2. Maximum slope length for sheet flow shall be 100 feet unless additional justification is provided.
      3. The Kinematic wave method shall be used to estimate the travel time for sheet flow.

   ii. For shallow concentrated flow segment:
      1. The travel time for shallow concentrated flow shall be obtained using the velocity determined from Figure 3-1 of Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).

   iii. *For channel flow*:
      1. Manning's roughness coefficient for channel flow shall be determined using the method described in the District's Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.
      2. HEC-RAS velocity or the Manning's equation may be used to estimate the travel time for channel flow.
      3. The discharge for upstream sub-basins shall be 2/3 times the 100-yr discharge value calculated with Regional Regression Equation 13 (Thomas et al., 1997). Sub-basins with channel flow from an upstream basin shall use the 100-yr discharge value calculated with Regional Regression Equation 13.

c. ***Transform:*** The SCS Unit Hydrograph method shall be used.

d. ***Channel Routing:***

i. *Routing in Natural Channels:* Runoff shall be routed using the Modified-Puls method for natural channels with the slope less than 1.5%. It may also be used for steeper channels. A storage discharge table is required if HEC-HMS is used. Such a table can be developed using cross-sections and slopes derived from a Manning normal depth analysis or HEC-RAS (COE, 2016). The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manual. Initial discharge to estimate HEC-RAS velocity for channel flow should be determined using discharge calculated with USGS Regression Equation 13 (Thomas et al., 1997).

ii. *Routing in Constructed Channels and Steep Channel:* The Kinematic Wave Method may be used for constructed channels and natural channels with slopes greater than 1%. Reach length, slope, bottom width and side slope may be obtained using the data utilized for watershed delineation (e.g. 2-foot contour interval contour maps, Digital Elevation Models (DEM) or Digital Terrain Models (DTM). Selection of Manning's n values shall conform to the guidance in Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*. The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manuals.

e. ***Rainfall:*** Technical Policy *TECH-010, Rainfall Input for Hydrologic Modeling* provides the requirements for rainfall input. A representative point near the centroid of the watershed shall be used.

f. ***Rainfall Areal Reduction:*** Areal reduction shall be applied to watersheds larger than 1 square mile. Areal reduction shall be estimated using Hydro-40 (National Weather Service, 1984) for the watershed and event of interest (i.e. same tables as contained in Arizona State Standard [SS10-07]).

g. ***Rainfall Distribution:*** The following rainfall distributions shall be used, with the highest peak discharge selected in order to determine the critical storm (i.e. the storm that produces the highest discharge):

i. **SCS Type II (3-hr Storm):** The 3-hr distribution shall be used as the local storm. In general, this includes watersheds with a time of concentration (T_c) equal to or less than three hours (Haan et al 1994).

ii. **SCS Type I (24 hr Storm):** The SCS Type I rainfall (NRCS, 1986) may apply for general storms on watersheds with times of concentration (T_c) greater than three hours.

iii. **Hypothetical (1-hr Storm**): The one-hour storm based on the intensity duration frequency data may apply to the smallest watersheds that generate a regulatory discharge, especially within an urban environment.

h. ***Impervious Percentage:*** Impervious cover percentage (Imp. %) shall be determined as follows, unless an alternative is justified:

i. For areas that are already developed, Pima County's most current Land-Use-Land-Cover Image (LULC) should be used. Class Fields to be included in the Imp. % shall include "Impervious", "Roads", and "Structures". The Class Field of "Barren/Bedrock" should be evaluated and incorporated into the Imp. % if deemed appropriate.

ii. When upstream undeveloped properties are owned by the federal, state or local jurisdictions, it is assumed to either remain undeveloped or to be developed in such a way that limits post-development peak discharges to no more than pre-development discharges. As such, no additional considerations should be made for future development.

iii. When upstream undeveloped properties are privately owned, it is assumed to be developed to the maximum current zoning density. Modeling shall account for future development within these areas by using the average percent impervious cover from the PC-HYDRO table.

D. **Comparison of peak discharge**: Peak discharges shall be compared with the peak discharges obtained from USGS regression equations obtained from **Table 9** of *Methods for Estimating Magnitude and Frequency of Floods in Arizona, Developed with Unregulated and Rural Peak-Flow Data through Water Year 2010,* (USGS, 2014). Eastern Pima County is represented by "Region 5" and western Pima County is represented by "Region 3".

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APPROVED BY:

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Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 4/1/11Date(s)
Revised: 11/16/12, 3/6/20, 5/18/21

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Appendix

USGS SIR 2014-5211 Table 9: The current regional regression relationships is Region 3 for western Pima County and Region 5 for eastern Pima County. This method predicts peak discharge in cfs (Qp).

Table 9. Regional regression equations for predicting the 50–, 20–, 10–, 4–, 2–, 1–, 0.5–, and 0.2–percent annual exceedance probability flows in 5 flood regions of Arizona.

[*DRNAREA*, drainage area in square miles; *PRECIP*, mean annual precipitation in inches; *ELEV*, mean basin elevation in feet]

P–percent annual exceedance probability	Regional regression equations
Flood region 1 (High Elevation) regression equation	
50	$17.4\ (DRNAREA)^{0.655}$
20	$42.1\ (DRNAREA)^{0.625}$
10	$65.5\ (DRNAREA)^{0.613}$
4	$103\ (DRNAREA)^{0.604}$
2	$136\ (DRNAREA)^{0.601}$
1	$173\ (DRNAREA)^{0.599}$
0.5	$215\ (DRNAREA)^{0.599}$
0.2	$279\ (DRNAREA)^{0.599}$
Flood region 2 (Colorado Plateau) regression equation	
50	$53.2\ (DRNAREA)^{0.505}$
20	$142\ (DRNAREA)^{0.476}$
10	$236\ (DRNAREA)^{0.460}$
4	$406\ (DRNAREA)^{0.442}$
2	$573\ (DRNAREA)^{0.431}$
1	$778\ (DRNAREA)^{0.421}$
0.5	$1{,}028\ (DRNAREA)^{0.413}$
0.2	$1{,}429\ (DRNAREA)^{0.403}$
Flood region 3 (Western Basin and Range) regression equation	
50	$2.78\ (DRNAREA)^{0.462}(PRECIP)^{2.229}10^{(-0.351*ELEV/1{,}000)}$
20	$12.8\ (DRNAREA)^{0.474}(PRECIP)^{1.706}10^{(-0.208*ELEV/1{,}000)}$
10	$26.7\ (DRNAREA)^{0.479}(PRECIP)^{1.447}10^{(-0.132*ELEV/1{,}000)}$
4	$89.1\ (DRNAREA)^{0.495}(PRECIP)^{0.839}$
2	$129\ (DRNAREA)^{0.505}(PRECIP)^{0.831}$
1	$183\ (DRNAREA)^{0.516}(PRECIP)^{0.812}$
0.5	$256\ (DRNAREA)^{0.527}(PRECIP)^{0.789}$
0.2	$384\ (DRNAREA)^{0.539}(PRECIP)^{0.758}$

Table 9. Regional regression equations for predicting the 50–, 20–, 10–, 4–, 2–, 1–, 0.5–, and 0.2–percent annual exceedance probability flows in 5 flood regions of Arizona.—Continued

[*DRNAREA*, drainage area in square miles; *PRECIP*, mean annual precipitation in inches; *ELEV*, mean basin elevation in feet]

P–percent annual exceedance probability	Regional regression equations
Flood region 4 (Central Highlands) regression equation	
50	$54.7\ (DRNAREA)^{0.664}$
20	$51.2\ (DRNAREA)^{0.658}(PRECIP)^{0.903}10^{(-0.135*ELEV/1{,}000)}$
10	$43.2\ (DRNAREA)^{0.643}(PRECIP)^{1.204}10^{(-0.150*ELEV/1{,}000)}$
4	$33.6\ (DRNAREA)^{0.624}(PRECIP)^{1.528}10^{(-0.160*ELEV/1{,}000)}$
2	$30.8\ (DRNAREA)^{0.614}(PRECIP)^{1.687}10^{(-0.161*ELEV/1{,}000)}$
1	$30.0\ (DRNAREA)^{0.605}(PRECIP)^{1.805}10^{(-0.161*ELEV/1{,}000)}$
0.5	$30.6\ (DRNAREA)^{0.598}(PRECIP)^{1.893}10^{(-0.161*ELEV/1{,}000)}$
0.2	$33.3\ (DRNAREA)^{0.591}(PRECIP)^{1.976}10^{(-0.160*ELEV/1{,}000)}$
Flood region 5 (Southeastern Basin and Range) regression equation	
50	$10^{(6.363-4.386\ DRNAREA^{-0.060})}$
20	$10^{(5.868-3.506\ DRNAREA^{-0.080})}$
10	$10^{(5.778-3.218\ DRNAREA^{-0.090})}$
4	$10^{(5.757-2.988\ DRNAREA^{-0.100})}$
2	$10^{(5.696-2.795\ DRNAREA^{-0.110})}$
1	$10^{(5.651-2.634\ DRNAREA^{-0.120})}$
0.5	$10^{(5.761-2.638\ DRNAREA^{-0.120})}$
0.2	$10^{(5.750-2.502\ DRNAREA^{-0.130})}$

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO: Technical Policy, TECH-018 **EFFECTIVE DATE: November 16, 2012**
REVISION DATE: 5/18/21

POLICY NAME: Acceptable Model Parameterization for Determining Peak Discharges

PURPOSE

The purpose of this technical policy is to standardize the parameterization of hydrologic models for ~~every~~ concentration points of interest within a **contributing-flow** regime. Policy regarding parameterization of hydrologic models within distributary-flow regimes is provided under Technical Policy *TECH-033, Criteria for Two-Dimensional Modeling*.

BACKGROUND

When determining peak discharges, a computer-based hydrologic model or previously-accepted discharge value may be used. Technical Policy *TECH-015, Hydrologic Model Selection for Peak Discharge Determination,* describes which models are acceptable for determining peak discharges. ~~Pima County Hydrology Procedures shall be used for riverine watersheds with an area less than 1 square mile, and it may be used for watersheds up to 10 square miles. HEC-HMS may be applied to riverine watersheds with an area larger than 1 square mile, and is particularly useful for evaluating watersheds that have detention basins or where channel routing or storage is important.~~ This policy describes which parameterization shall be used for submittals to the Pima County Regional Flood Control District (District).

POLICY

A. **Watershed Delineation:** The accuracy of watershed delineation and flow path identification is critical in hydrologic modeling. The watershed delineation shall leverage high-resolution topography that meets or exceeds the United States Geological Survey (USGS) 3-D Elevation Program standards (FEMA, 2018). ~~The District requires the use of 2-foot contour interval (or finer where available) maps, such as the Pima Association of Governments (PAG) contour maps for delineation of basin boundaries and flow paths in all areas other than steep terrain.~~ In areas of steep terrain, or where high-resolution topography ~~2-foot or finer contour interval maps~~ is~~are~~ not available, ~~U.S. Geologic Survey (~~USGS~~)~~ contour maps (7.5 minute series) may be accepted. At the discretion of the District, it may be a requirement that topographic data be sealed by an Arizona registered civil engineer (PE), or land surveyor (RLS).

   For watershed delineation within ~~In~~ regulatory sheetflood areas, or areas with potential distributary flow patterns, two-dimensional modeling may be required. Technical Policy *TECH-033, Criterial for Two-Dimensional Modeling* provides the criteria for watershed delineation when performing two-dimensional modeling.

~~, both 2-foot or finer contour interval maps and aerial photos shall be used with a resolution sufficient to determine flow paths and watershed boundaries. If Geo-HMS (COE, 2003) is used, Digital Elevation Models (DEMs) or Digital Terrain Models (DTMs) or DEMs derived from Lidar data from PAG or other reputable vendors, may be used. With the approval of the District, alternative topographic data, such as stereo photography, may be used.~~

~~A.~~B. **Pima County Hydrology Procedures:** Peak-discharge calculations performed using the Pima County Hydrology Procedures shall follow the guidance for parameterization provided in the PC-~~-~~HYRDO~~ydro~~ User Guide (~~Arroyo Engineering, 2007~~District, 2019).

C. **HEC-1 and HEC-HMS:** Peak discharges calculated using HEC-HMS (COE, 2018~~06~~) or HEC-1 (COE, 1998) shall employ the following parameterization:

a. ***Rainfall Loss Method:*** Models shall employ the U.S Soil Conservation Service (SCS) Curve Number method using the Curve Number tables. Vegetation map and Hydrologic Soils Group map associated with the PC-~~-~~HYDRO~~Hydro~~ User Guide (~~Arroyo Engineering~~District, 2019~~07~~) shall be used. The default vegetation cover percent provided in the PC-HYDRO ~~Hydro~~ User Guide (District, 2019~~Arroyo Engineering, 2007~~) shall be used unless additional justification is provided. The Curve Number shall not be adjusted for rainfall intensity or antecedent moisture conditions.

b. ***Time of Concentration Calculation:*** The modified U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (T_c) calculation shall be employed (USDA-NRCS, 1986). The Tc shall be calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow, along the primary flow path.

i. For sheet flow segment:

1. Manning's roughness coefficient for sheet flow shall be obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).
2. Maximum slope length for sheet flow shall be 100 feet unless additional justification is provided.
3. The Kinematic wave method shall be used to estimate the travel time for sheet flow.

ii. For shallow concentrated flow segment:

1. The travel time for shallow concentrated flow shall be obtained using the velocity determined from Figure 3-1 of Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).

iii. *For channel flow*:

1. Manning's roughness coefficient for channel flow shall be determined using the method described in the District's Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.
2. HEC-RAS velocity or the Manning's equation may be used to estimate the travel time for channel flow.
3. The discharge for upstream sub-basins shall be 2/3 times the 100-yr discharge value calculated with Regional Regression Equation 13 (Thomas et al., 1997). Sub-basins with channel flow from an upstream basin shall use the 100-yr discharge value calculated with Regional Regression Equation 13.

c. ***Transform:*** The SCS Unit Hydrograph method shall be used.

d. ***Channel Routing:***

i. *Routing in Natural Channels:* Runoff shall be routed using the Modified-Puls method for natural channels with the slope less than 1.5%. It may also be used for steeper channels. A storage discharge table is required if HEC-HMS is used. Such a table can be developed using cross-sections and slopes derived from a Manning normal depth analysis or HEC-RAS (COE, ~~2001~~2016). The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manual. Initial discharge to estimate HEC-RAS velocity for channel flow should be determined using discharge calculated with USGS Regression Equation 13 (Thomas et al., 1997).

ii. *Routing in Constructed Channels and Steep Channel:* The Kinematic Wave Method may be used for constructed channels and natural channels with slopes greater than 1%. Reach length, slope, bottom width and side slope may be obtained using the data utilized for watershed delineation (e.g. 2-foot contour interval contour maps, Digital Elevation Models (DEM) or Digital Terrain Models (DTM). Selection of Manning's n values shall conform to the guidance in Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*. The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manuals.

e. ***Rainfall:*** ~~The NOAA 14 Upper 90% rainfall shall be used as described in the District's~~ Technical Policy *TECH-010, Rainfall Input for Hydrologic Modeling* provides the requirements for rainfall input. A representative point near the centroid of the watershed shall be used.

~~. Point rainfall depth shall be evaluated for a watershed, based on the latitude and longitude of the centroid of the watershed. If appreciable elevation~~

~~change occurs on a watershed, users should use different values for higher and lower elevations.~~

f. ***Rainfall Areal Reduction:*** Areal reduction shall be applied to watersheds larger than 1 square mile. Areal reduction shall be estimated using Hydro-40 (National Weather Service, 1984) for the watershed and event of interest (i.e. same tables as contained in Arizona State Standard [SS10-07]).

g. ***Rainfall Distribution:*** The following rainfall distributions shall be used, with the highest peak discharge selected in order to determine the critical storm (i.e. the storm that produces the highest discharge)~~-~~:

i. ~~**1.**~~ **SCS Type II (3-hr Storm):** The 3-hr distribution shall be used as the local storm. In general, this includes watersheds with a time of concentration (T_c) equal to or less than three hours (Haan et al 1994).

ii. ~~**3.**~~ **SCS Type I (24 hr Storm):** The SCS Type I rainfall (NRCS, 1986) may apply for general storms on watersheds with times of concentration (T_c) greater than three hours.

iii. ~~**City of Tucson**~~**Hypothetical (1-hr Storm**): The one-hour storm based on the intensity duration frequency data may apply to the smallest watersheds that generate a regulatory discharge, especially within an urban environment.

h. ***Impervious Percentage:*** Impervious cover percentage (Imp. %) shall be determined as follows, unless an alternative is justified:

i. For areas that are already developed, Pima County's most current Land-Use-Land-Cover Image (LULC) should be used ~~to estimate a watershed's percent of impervious (Imp. %) cover~~. Class Fields to be included in the Imp. % shall include "Impervious", "Roads", and "Structures". The Class Field of "Barren/Bedrock" should be evaluated and incorporated into the Imp. % if deemed appropriate.

ii. When upstream undeveloped properties are owned by the federal, state or local jurisdictions, it is assumed to either remain undeveloped or to be developed in such a way that limits post-development peak discharges to no more than pre-development discharges. As such, no additional considerations should be made for future development.

~~i.~~iii. When upstream undeveloped properties are privately owned, it is assumed to be developed to the maximum current zoning density. Modeling shall account for future development within these areas by using the average percent impervious cover from the PC-HYDRO table.

D. **Comparison of peak discharge**: Peak discharges shall be compared with the peak discharges obtained from USGS r~~R~~egression e~~E~~quations obtained from **Table 9** of *Methods*

for Estimating Magnitude and Frequency of Floods in Arizona, Developed with Unregulated and Rural Peak-Flow Data through Water Year 2010, ~~13~~ (USGS, 2014~~Thomas et al., 1997~~). Eastern Pima County is represented by "Region 5" and western Pima County is represented by "Region ~~and/or the equations (both urban and rural) developed by Eychaner (1984) (See Appendix), and existing regulatory discharge estimates. Appropriate Basin Development Factors (BDFs) shall be used for urban areas. The discharge may also be compared with graphs prepared by Arizona Department of Transportation (ADOT, 1993).~~ 3".

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APPROVED BY:

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Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 4/1/11
Date(s) Revised: 11/16/12, 3/6/20, 5/18/21

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Appendix

USGS SIR 2014-5211~~Regression Equat~~ Table 9~~ion 13~~: The current regional regression relationships is Region 3 for western Pima County and Region 5 for eastern Pima County~~southern Arizona is regression equation 13 from Thomas et al (1994)~~. This method predicts peak discharge in cfs (Qp).

~~1.) as a function of watershed Area (square miles) only. It has the form:~~

~~2.)~~ $Qp100 = 10^{(5.52-2.42*A^{-0.12})}$

Table 9. Regional regression equations for predicting the 50–, 20–, 10–, 4–, 2–, 1–, 0.5–, and 0.2–percent annual exceedance probability flows in 5 flood regions of Arizona.

[*DRNAREA*, drainage area in square miles; *PRECIP*, mean annual precipitation in inches; *ELEV*, mean basin elevation in feet]

P–percent annual exceedance probability	Regional regression equations
Flood region 1 (High Elevation) regression equation	
50	$17.4\ (DRNAREA)^{0.655}$
20	$42.1\ (DRNAREA)^{0.625}$
10	$65.5\ (DRNAREA)^{0.613}$
4	$103\ (DRNAREA)^{0.604}$
2	$136\ (DRNAREA)^{0.601}$
1	$173\ (DRNAREA)^{0.599}$
0.5	$215\ (DRNAREA)^{0.599}$
0.2	$279\ (DRNAREA)^{0.599}$
Flood region 2 (Colorado Plateau) regression equation	
50	$53.2\ (DRNAREA)^{0.505}$
20	$142\ (DRNAREA)^{0.476}$
10	$236\ (DRNAREA)^{0.460}$
4	$406\ (DRNAREA)^{0.442}$
2	$573\ (DRNAREA)^{0.431}$
1	$778\ (DRNAREA)^{0.421}$
0.5	$1{,}028\ (DRNAREA)^{0.413}$
0.2	$1{,}429\ (DRNAREA)^{0.403}$
Flood region 3 (Western Basin and Range) regression equation	
50	$2.78\ (DRNAREA)^{0.462}(PRECIP)^{2.229}10^{(-0.351*ELEV/1{,}000)}$
20	$12.8\ (DRNAREA)^{0.474}(PRECIP)^{1.706}10^{(-0.208*ELEV/1{,}000)}$
10	$26.7\ (DRNAREA)^{0.479}(PRECIP)^{1.447}10^{(-0.132*ELEV/1{,}000)}$
4	$89.1\ (DRNAREA)^{0.495}(PRECIP)^{0.839}$
2	$129\ (DRNAREA)^{0.505}(PRECIP)^{0.831}$
1	$183\ (DRNAREA)^{0.516}(PRECIP)^{0.812}$
0.5	$256\ (DRNAREA)^{0.527}(PRECIP)^{0.789}$
0.2	$384\ (DRNAREA)^{0.539}(PRECIP)^{0.758}$

Table 9. Regional regression equations for predicting the 50–, 20–, 10–, 4–, 2–, 1–, 0.5–, and 0.2–percent annual exceedance probability flows in 5 flood regions of Arizona.—Continued

[*DRNAREA*, drainage area in square miles; *PRECIP*, mean annual precipitation in inches; *ELEV*, mean basin elevation in feet]

P–percent annual exceedance probability	Regional regression equations
Flood region 4 (Central Highlands) regression equation	
50	$54.7\ (DRNAREA)^{0.664}$
20	$51.2\ (DRNAREA)^{0.658}(PRECIP)^{0.903}10^{(-0.135*ELEV/1{,}000)}$
10	$43.2\ (DRNAREA)^{0.643}(PRECIP)^{1.204}10^{(-0.150*ELEV/1{,}000)}$
4	$33.6\ (DRNAREA)^{0.624}(PRECIP)^{1.528}10^{(-0.160*ELEV/1{,}000)}$
2	$30.8\ (DRNAREA)^{0.614}(PRECIP)^{1.687}10^{(-0.161*ELEV/1{,}000)}$
1	$30.0\ (DRNAREA)^{0.605}(PRECIP)^{1.805}10^{(-0.161*ELEV/1{,}000)}$
0.5	$30.6\ (DRNAREA)^{0.598}(PRECIP)^{1.893}10^{(-0.161*ELEV/1{,}000)}$
0.2	$33.3\ (DRNAREA)^{0.591}(PRECIP)^{1.976}10^{(-0.160*ELEV/1{,}000)}$
Flood region 5 (Southeastern Basin and Range) regression equation	
50	$10^{(6.363-4.386\ DRNAREA^{-0.060})}$
20	$10^{(5.868-3.506\ DRNAREA^{-0.080})}$
10	$10^{(5.778-3.218\ DRNAREA^{-0.090})}$
4	$10^{(5.757-2.988\ DRNAREA^{-0.100})}$
2	$10^{(5.696-2.795\ DRNAREA^{-0.110})}$
1	$10^{(5.651-2.634\ DRNAREA^{-0.120})}$
0.5	$10^{(5.761-2.638\ DRNAREA^{-0.120})}$
0.2	$10^{(5.750-2.502\ DRNAREA^{-0.130})}$

3.) Eychaner 1984 (rural): This is a USGS publication that was prepared in cooperation with the City and County. It presents a series of regression equations that rely on watershed area (sq. miles), main channel slope (%), channel length (miles) and a shape factor to account for the differences in runoff noted between long watersheds and more traditionally-shaped watersheds. The equation for the 100 year peak discharge is:

$$Qp_{100} = 10^{(3.044+0.646(\log A)-0.049(\log A)^2+0.729(\log S)-0.367(\log S)^2-0.614(\log S)(LogSh))}$$

The shape factor (Sh) is calculated as (channel length)^2/(Area)

3.) Eychaner 1984 (urban): This equation adjusts Eychaner's rural equation to account for the amount of impervious area, channel lining and channel modification. It is:

$$Qp_{100} = 7.7A^{0.15}(13 - BDF)^{-0.32}Qp100^{0.82}$$

The Basin Development Factor (BDF) is a scoring factor to account for the degree of urbanization. The specific scoring is based on four factors described in pages 10-13 of the

~~manual.The lower, middle and upper portions of a watershed are scored separately and the results are summed. The maximum BDF score is 12, and a score of 0 indicates that the rural equation should be used. (The Qp100 in the equation is the Qp100 calculated using Eychaner's rural method described in section 2 above.)~~

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO.: Technical Policy, TECH-022 **EFFECTIVE DATE: November 2, 2009**
REVISED DATE: 5/18/21

POLICY NAME: Use of Flood Openings, Applicability and Requirements

PURPOSE: To clarify 16.26.030.E of the Ordinance regarding the applicability of the requirement to provide flood openings/vents (hereafter, openings) in crawl spaces, detached non-habitable structures or attached non-habitable portions of structures such as attached garages, that have enclosed areas with finished floor elevation(s) below the Regulatory Flood Elevation (RFE). This policy also provides guidance on types of allowable screens, grates, louvers or other engineered coverings for these flood openings.

BACKGROUND: A structure with a fully enclosed area below the Base Flood Elevation (BFE) may be subject to flood damage due to the hydrostatic or hydrodynamic force of the flood waters unless the structure is designed and constructed to address these safety concerns, such as through the use of flood openings. Pursuant to the Code of Federal Regulations (CFR) 44CFR 60.3(C)(5), the District is required to ensure that any new structure or substantial improvement with fully enclosed areas below the BFE that is used solely for the parking of vehicles, building access, or storage in an area other than a basement be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the automatic entry and exit of floodwaters. In addition, A.R.S. § 48-3609 requires any residential structure to be elevated at or above the RFE, which is one foot above the BFE. Section 16.26.030.E of the Floodplain Management Ordinance (Ordinance) reiterates this requirement, including the provisions prescribing some minimum design criteria for flood openings including:

- A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding,
- The bottom of each opening shall be no higher than one foot above grade,
- The openings may be equipped with screens, louvers, valves or other coverings provided that they permit the automatic entry and exit of floodwaters.

The one foot of freeboard required by A.R.S. § 48-3609 is more restrictive than the CFR, and has the potential to create a situation in which the flood openings do not serve the intended purpose, such as cases where a residence is constructed to the RFE but its attached garage, due to the tire stop, falls just below the RFE.

After discussion with Arizona Department of Water Resources, this Policy needed to be changed to comply with minimum Arizona Revised Statue freeboard requirements. As such, the 2021 revision requires attached garages with floors below the RFE to be constructed of floodproof materials up to the RFE and have flood openings. The previous guidance did not require flood openings if the floor elevation of an attached garage was within six inches of the RFE.

The 2021 revision is also modified to address FEMA Technical Bulletin 1 which specifies that, “Note that the openings (or those portions that count towards the required net open area) must be located below the BFE. In areas with shallow flood depths, this may require positioning the openings closer to grade than the maximum 1 foot allowed.” Technical Bulletin 1 further states that communities with a

freeboard requirement may regulate to the Design Flood Elevation (DFE), which is equivalent to the Regulatory Flood Elevation, and that references to BFE in the bulletin should be construed as references to the DFE (RFE). Due to the additional foot of freeboard required by the state of Arizona, for structures with a floor elevation below the RFE, the required net open area of flood openings must be located below the RFE.

Additionally, both the CFR and the Ordinance allows the openings to be screened as long as they continue to allow the automatic entry and exit of floodwaters, but no guidance exists regarding the types of screens or louvers that are acceptable. A screen with too fine a mesh has the potential to reduce the effective size of the opening, especially when debris accumulation is considered.

This policy is intended to ensure that flood openings, when required, serve their intended purpose, and to provide guidance on acceptable design and screening of flood openings. It is supplemental to FEMA Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures*, which should be used for additional information, as it provides guidance on the use of specific types of flood openings.

POLICY:

I. Applicability

This policy applies to non-habitable structures or non-habitable portions of structures (collectively, enclosed areas) that are used solely for the parking of vehicles, building access, or limited storage in an area other than a basement, with an enclosed area below the RFE. Additional applicability information is found in *Technical Policy TECH-023.*

Structures that have only three walls are not subject to hydrostatic forces and as such flood openings are not required by FEMA for this purpose. However, the placement of flood openings may be required by the District in order to provide relief of hydrodynamic flood forces. To be considered a three-walled structure, the open side must contain only the minimum amount of structural support for that side of the building, with no additional wall enclosure proposed. Walls that contain openings that are sized to allow for possible installation of a garage door(s) are not considered to be either open nor a three-walled structure.

Structures that have a dirt floor are subject to this policy if the floor elevation is lower than the RFE.

II. Flood Opening Use

If allowed pursuant to *Technical Policy TECH-023*, structures with an enclosed area below the RFE shall be constructed with flood openings as described in Section III. Flood openings are not allowed in habitable structures or portions of habitable structures, except for crawl spaces, attached garages and storage spaces that are accessed solely by an exterior entrance with no doorway between the habitable space and the storage area.

III. Flood Opening Requirements

When flood openings are required the following standards shall apply:

A. Flood openings must allow for the automatic entry and exit of floodwaters.
B. Doorways do not qualify as an opening because they do not allow for the automatic entry and exit of floodwaters. Overhead garage-type doors also do not qualify as flood openings.

However, while discouraged, flood openings may be placed in overhead garage doors at the discretion of the District based on the availability of other locations for openings. If flood openings are placed in garage doors, this must be noted in the specific covenants to be signed by the property owner.

C. Flood openings are only allowed in human doorway doors when retrofitting nonconforming uses, but are discouraged.
D. Every enclosed area is required to have at least two flood openings on exterior walls. Flood openings must be installed on at least two sides of each enclosed area.
    1. If possible, openings should be placed on opposing walls, preferably in line with the direction of flow.
    2. Flood openings should be evenly distributed to ensure the most effective entry and exit of flood waters.
    3. In the case of an attached garage in which there are not two opposing walls exposed to flow because of the house, flood openings may be placed on adjacent walls.
E. Any portion of an opening above the RFE is not considered to be effective for the purpose of providing relief from hydrostatic and hydrodynamic forces and shall not be included in the total opening area calculation necessary to meet the 1 square inch of opening per square foot of enclosed area requirement. This may require the bottom of the openings to be less than the maximum 1 foot above grade.
F. The bottom of all openings shall be:
    1. less than 12 inches above adjacent natural grade, as measured at the location of the opening, **or**
    2. as close as possible to the floor elevation of an enclosure having a floor elevated above the BFE.
G. The interior grade or floor along the lowest side of the building must be at or above the exterior grade across the entire length of the lowest side, and there must be positive surface drainage away from the building; otherwise, the enclosure will be considered a basement and thus not allowed.
H. If a structure is elevated on a stem wall and the area behind the stem wall is not backfilled, fill may not be placed against the outside of the stem wall unless openings are placed through the fill. Otherwise the area within the limits of the stem wall is considered to be a basement, which is not allowed within a regulatory floodplain.

IV. Submittal Requirements

Permit applications for structures that will not be elevated at or above RFE shall contain the following detailed information:

A. The size, location, height above natural grade of the top and bottom of the flood openings and the type of opening cover (if used). Alternatively, the opening size, top/bottom height above natural grade and covering type (if any) may be presented as a note or as an annotated side-view detail but locations of all openings shall be shown on the site plan and all relevant plan sheets.
B. Flood openings and covers shall comply with Sections V and VI below.
C. The specification of flood-resistant materials to be used for all construction materials below the RFE (as addressed in *Technical Policy TECH-021)*. All materials used below the RFE must be flood-resistant materials.
D. A signed and notarized covenant, to be prepared by the District after permit application for signature by the property owner(s),which states that the structure or enclosed area is not elevated to the RFE and shall remain non-habitable unless brought into compliance with the rules and regulations for habitable structures or areas.

V. Flood Opening Covers

NFIP rules allow flood openings to be covered with louvers, grates, screens or engineered vents. The following options are acceptable for use. See Section VI for requirements to document compliance.

A. Screen, provided:
   1. The mesh openings are at least:
      a. 1/4 inch for BFEs 1 foot or less in depth
      b. 1/2 inch for BFEs greater than 1 foot and up to 2 feet in depth
      c. 1 inch for BFEs greater than 2 feet and up to 3 feet in depth.
      d. For flow greater than 3 feet, screen size must be determined by an Arizona registered civil engineer.

B. Grates or Louvers, provided:
   1. The louvers are permanently open (no hinged or closeable louvers except if designed to automatically open when exposed to floodwaters as demonstrated by a report from an Arizona registered civil engineer or as approved by FEMA).
   2. The minimum opening size of grates or spacing between louvers is at least:
      a. 1/2 inch apart for BFEs 1 foot or less in depth
      b. 1 inch apart for BFEs greater than 1 foot and up to 2 feet in depth
      c. 2 inches apart for BFEs greater than 2 feet and up to 3 feet in depth.
      d. For flow depths of greater than 3 feet, covers must be designed by an Arizona registered civil engineer.
   3. The area taken up by the solid portion of the grates or louvers must be subtracted from the total opening size so that only the total area open to flow is considered.

C. Smartvents™, USA Flood Air Vents, FloodFlaps® or other FEMA approved opening covers.

D. Other methods of covering flood openings may be used if supported by a report from an Arizona registered civil engineer.

VI. Documentation of Compliance

It is the responsibility of the registered professional completing the Elevation Certificate to accurately measure the number of flood openings and the total amount of space open to flow. This requirement includes calculating the area of the openings that are taken up by grates, louvers, etc. and are thus ineffective to flow.

A. Documentation of Openings with No Covers

If no flood opening covers are used the four required color photographs taken for the Elevation Certificate may be sufficient documentation of compliance provided that they clearly show all four sides of the structure and all of the flood openings are visible.

B. Documentation of Openings with Covers

If flood opening covers are used, in addition to the color photographs outlined in Section VI.A, at least one additional color photograph shall be required that shows a close-up view of a typical opening. If more than one flood opening cover type is used, a color photograph of each type must be provided. The surveyor must state that the close-up photo is typical of all openings or of a specified number of the openings. The close-up photo(s) of the opening cover(s) may not be used as a substitute for one of the four required photographs for the Elevation Certificate.

C. Documentation of Openings with Engineered Vents

If engineered flood vents are used, such as Smartvents™, USA Flood Air Vents, FloodFlaps® or other FEMA approved opening covers, the specification sheet for the specific model used shall be attached to the Elevation Certificate for the structure. If site-specific

engineered vents are used, an As-Built certification from the engineer of record shall be attached to the Elevation Certificate for the structure.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 11/2/2009
Date(s) Revised: 11/2/15, 5/18/21

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO.: Technical Policy, TECH-022 **EFFECTIVE DATE:** November 2, 2009
REVISED DATE: ~~**November 2, 2015**~~

5/18/21

POLICY NAME: Use of Flood Openings, Applicability and Requirements

PURPOSE: To clarify 16.26.030.E of the Ordinance regarding the applicability of the requirement to provide flood openings ~~(~~/vents (hereafter, openings) in crawl spaces, detached non-habitable structures or attached non-habitable portions of structures such as attached garages, that have enclosed areas with finished floor elevation(s) below the Regulatory Flood Elevation (RFE). This policy also provides guidance on types of allowable screens, grates, louvers or other engineered coverings for these flood openings.

BACKGROUND: A structure with a fully enclosed area below the B~~b~~ase F~~f~~lood ~~e~~Elevation (BFE) may be subject to flood damage due to the hydrostatic or hydrodynamic force of the flood waters unless the structure is designed and constructed to address these safety concerns, such as through the use of flood openings. Pursuant to the Code of Federal Regulations (CFR) 44CFR 60.3(C)(5), the District is required to ensure that any new structure or substantial improvement with fully enclosed areas below the BFE that is used solely for the parking of vehicles, building access, or storage in an area other than a basement be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the automatic entry and exit of floodwaters. In addition, A.R.S. § 48-3609 requires any residential structure to be elevated at or above the RFE, which is one foot above the BFE. Section 16.26.030.E of the Floodplain ~~and Erosion Hazard~~ Management Ordinance (Ordinance) reiterates this requirement, including the provisions prescribing some minimum design criteria for flood openings including:

- A minimum of two openings having a total net area of not less than one square inch for every square foot of enclosed area subject to flooding,
- The bottom of each opening shall be no higher than one foot above grade,
- The openings may be equipped with screens, louvers, valves or other coverings provided that they permit the automatic entry and exit of floodwaters.

~~In addition, A.R.S. § 48-3609 requires any residential structure to be elevated at or above the Regulatory Flood Elevation (RFE), which is one foot above the BFE. This additional requirement~~ The one foot of freeboard required by A.R.S. § 48-3609 is more restrictive than the CFR, and has the potential to create a situation in which the flood openings do not serve the intended purpose, such as cases where a residence is constructed to the RFE but its attached garage, due to the tire stop, falls just below the RFE. ~~In this instance, applying the flood opening requirement may result in the either the opening being well above the RFE, or if the garage is already elevated on a backfilled stem wall, the opening would be located in the backfilled area. Neither of these provides any additional protection from flood damage.~~

After discussion with Arizona Department of Water Resources, this Policy needed to be changed to comply with minimum ~~State standards~~Arizona Revised Statue freeboard requirements. As such, the 202~~0~~1 revision requires attached garages with floors below the RFE to be constructed of floodproof

materials up to the RFE and have flood openings. The previous guidance did not require flood openings if the floor elevation of an attached garage was within six inches of the RFE.

The 2020~~0~~1 revision is also modified to address FEMA Technical Bulletin 1 which specifies that, "Note that the openings (or those portions that count towards the required net open area) must be located below the BFE. In areas with shallow flood depths, this may require positioning the openings closer to grade than the maximum 1 foot allowed." Technical Bulletin 1 further states that communities with a freeboard requirement may regulate to the Design Flood Elevation (DFE), which is equivalent to the Regulatory Flood Elevation, and that references to BFE in the bulletin should be construed as references to the DFE (RFE). Due to the additional foot of freeboard required by the state of Arizona, for structures with a floor elevation below the RFE, the required net open area of flood openings must be located below the RFE.

Additionally, both the CFR and the Ordinance allows the openings to be screened as long as they continue to allow the automatic entry and exit of floodwaters, but no guidance exists regarding the types of screens or louvers that are acceptable. A screen with too fine a mesh has the potential to reduce the effective size of the opening, especially when debris accumulation is considered.

This policy is intended to ensure that flood openings, when required, serve their intended purpose, and to provide guidance on acceptable design and screening of ~~openings of~~ flood openings. It is supplemental to FEMA Technical Bulletin 1~~-93~~, *Openings in Foundation Walls and Walls of Enclosures*, which should be used for additional information, as it provides guidance on the use of specific types of flood openings.

POLICY:

I. Applicability

This policy applies to non-habitable structures or non-habitable portions of structures (collectively, enclosed areas) that are used solely for the parking of vehicles, building access, or limited storage in an area other than a basement, with an enclosed area below the RFE. Additional applicability information is found in *Technical Policy TECH-023.*

Structures that have only three walls are not subject to hydrostatic forces and as such flood openings are not required by FEMA for this purpose. However, the placement of flood openings ~~is still recommended~~ may be required by the District in order to provide ~~so~~ relief ~~to~~ of ~~the~~ hydrodynamic flood forces ~~of the flood~~. To be considered a three-walled structure, the open side must contain only the minimum amount of structural support for that side of the~~e~~ building, with no additional wall enclosure proposed. Walls that contain openings that are sized to allow for possible installation of a garage door(s) ~~is~~are not considered to be either open nor a three-walled structure.

Structures that have a dirt floor are subject to this policy if the floor elevation is lower than the RFE.

II. Flood Opening Use ~~and Design Requirements~~

If allowed pursuant to *Technical Policy TECH-023*, structures with an enclosed area below the RFE shall be ~~vented~~ constructed with flood openings as described in Section III. Flood openings are not allowed in habitable structures or portions of habitable structures, except for crawl spaces, attached garages and storage spaces that are accessed solely by an exterior entrance with no doorway between the habitable space and the storage area.

~~as described below.~~

~~A. When enclosed areas are constructed as slab on grade, the bottom of each opening shall be no more than 1 foot above external natural grade as measured at the location of each individual opening.~~

~~B. Any portion of an opening more than two feet above the BFE is not considered to be effective for the purpose of providing relief from hydrostatic and hydrodynamic forces, and shall not be included in the total opening area calculation necessary to meet the 1 square inch of opening per square foot of enclosed area requirement.~~

~~C. Except for attached garages as noted in subpart d., when enclosed areas have floors elevated above natural grade but not elevated all the way to RFE, openings shall be placed as follows:~~

~~1. If the floor of the enclosure is below the BFE, the bottom of each opening shall be no more than 1 foot above the grade of the floor,~~

~~2. If the floor of the enclosure is above the BFE but below the RFE, the bottom of each opening shall be as close as possible to the grade of the floor. The purpose of this requirement is to ensure that the venting occurs below the RFE.~~

~~D. When the floor of an attached garage is elevated six inches or more above the BFE, flood openings are not required; however that portion of the attached garage below the RFE must comply with the flood-resistant materials requirement addressed in *Technical Policy 021*.~~

~~E. Flood openings shall be located on at least two walls of the enclosed area. Flood openings should be evenly distributed to ensure the most effective entry and exit of flood waters during a flood.~~

III. Flood Opening Requirements

When flood openings are required the following standards shall apply:

A. Flood openings must allow for the automatic entry and exit of floodwaters.

B. Doorways do not qualify as an opening because they do not allow for the automatic entry and exit of floodwaters. Overhead garage-type doors also do not qualify as flood openings. However, while discouraged, flood openings may be placed in overhead garage doors at the discretion of the District based on the availability of other locations for openings. If flood openings are placed in garage doors, this must be noted in the specific covenants to be signed by the property owner.

C. Flood openings are only allowed in human doorway doors when retrofitting nonconforming uses, but are discouraged.

D. Every enclosed area is required to have at least two flood openings on exterior walls. Flood openings must be installed on at least two sides of each enclosed area.

1. If possible, openings should be placed on opposing walls, preferably in line with the direction of flow.
2. Flood openings should be evenly distributed to ensure the most effective entry and exit of flood waters.
3. In the case of an attached garage in which there are not two opposing walls exposed to flow because of the house, flood openings may be placed on adjacent walls.

E. Any portion of an opening above the RFE is not considered to be effective for the purpose of providing relief from hydrostatic and hydrodynamic forces and shall not be included in the total opening area calculation necessary to meet the 1 square inch of opening per square foot of enclosed area requirement. This may require the bottom of the openings to be less than the maximum 1 foot above grade.

F. The bottom of all openings shall be:

1. less than 12 inches above adjacent natural grade, as measured at the location of the opening, **or**
2. as close as possible to the floor elevation of an enclosure having a floor elevated above the BFE.

G. The interior grade or floor along the lowest side of the building must be at or above the exterior grade across the entire length of the lowest side, and there must be positive surface drainage away from the building; otherwise, the enclosure will be considered a basement and thus not allowed.

H. If a structure is elevated on a stem wall and the area behind the stem wall is not backfilled, fill may not be placed against the outside of the stem wall unless openings are placed through the fill. Otherwise the area within the limits of the stem wall is considered to be a basement, which is not allowed within a regulatory floodplain.

~~III.~~IV. Submittal Requirements

Permit applications for structures that will not be elevated at or above RFE shall contain the following detailed information:

A. The size, location, ~~and~~ height above natural grade of the top and bottom of the flood openings and the type of opening cover (if used). ~~The opening locations shall be shown to scale on the site plan. T~~Alternatively, the opening size, top/bottom height above natural grade and covering type (if any) may be presented as a note ~~on the site plan~~ or as ~~part of~~ an annotated side-view detail but locations of all openings shall be shown on the site plan and all relevant plan sheets.

B. Flood openings and covers shall comply with Sections ~~4~~V and ~~5~~VI below.

C. The specification of flood-resistant materials to be used for all construction materials below the RFE (as addressed in *Technical Policy TECH-021)*. All materials used below the RFE must be flood-resistant materials.

D. A signed and notarized covenant, to be prepared by the District after permit application for signature by the property owner(s), ~~that~~ which states that the structure or enclosed area is not elevated to the RFE and shall remain non-habitable unless brought into compliance with the rules and regulations for habitable structures or areas.

~~E. If a non-habitable area is constructed below the RFE contrary to the terms and conditions of the permit, these covenants shall be signed and notarized prior to the release of any holds.~~

~~IV. Flood Opening Requirements~~

~~When flood openings are required the following standards shall apply:~~

~~A. Flood openings must allow for the automatic entry and exit of floodwaters.~~

~~B. Doorways do not qualify as an opening because they do not allow for the automatic entry and exit of floodwaters. Overhead garage doors also do not qualify as flood openings, however, flood openings may be placed in overhead garage doors. If flood openings are placed in garage doors, this must be noted in the specific covenants to be signed by the property owners.~~

~~C. Flood openings are only allowed in human doorway doors when flood proofing non-conforming uses.~~

~~D. Flood openings must be placed on a minimum of two different walls.~~

~~1. If possible, openings can be placed on opposing walls in line with the direction of flow.~~

~~2. In the case of an attached garage in which there are not two opposing walls exposed to flow because of the house, flood openings may be placed on adjacent walls.~~

~~E. The bottom of all openings shall be:~~

1. ~~less than 12 inches above adjacent natural grade as measured at the location of the opening for structures with an enclosed area that is not elevated,~~ **~~or~~**
2. ~~as close as possible to the floor elevation of an enclosure having a floor elevated above natural grade but below the RFE.~~

~~F. Any portion of an opening greater than 2.0 feet above the BFE shall not be included in the total opening calculation, as any open space above that elevation is not expected to provide any additional relief of hydrostatic pressure. As such, orienting openings horizontally maximizes the calculated area.~~

~~G. If a structure is elevated on a stem wall, and the area behind the stem wall is not backfilled, fill may not be placed against the outside of the stem wall unless openings are placed through the fill. Otherwise the area within the limits of the stem wall is considered to be a basement, which is not allowed within a regulatory floodplain.~~

V. Flood Opening Covers

NFIP rules allow flood openings to be covered with louvers, grates, ~~or~~ screens or engineered vents. The following ~~covers~~ options are acceptable for use~~:~~. See Section VI for requirements to document compliance.

A. Screen, provided:
   1. The mesh openings are at least:
      a. 1/4 inch for BFEs 1 foot or less in depth
      b. 1/2 inch for BFEs greater than 1 foot and ~~less than~~ up to 2 feet in depth
      c. 1 inch~~es~~ for BFEs greater than 2 feet and ~~less than~~ up to 3 feet in depth.
      d. For flow ~~depths of~~ greater than 3 feet ~~or more~~, screen size~~s~~ must be ~~designed~~ determined by an Arizona registered civil engineer.

B. Grates or Louvers, provided:
   1. The louvers are permanently open (no hinged or closeable louvers except if designed to automatically open when exposed to floodwaters as demonstrated by a report from an Arizona registered civil engineer or as approved by FEMA)~~.~~.
   2. The minimum opening size of grates or spacing between louvers is at least:
      a. 1/2 inch apart for BFEs 1 foot or less in depth
      b. 1 inch apart for BFEs greater than 1 foot and ~~less than~~ up to 2 feet in depth
      c. 2 inches apart for BFEs greater than 2 feet and ~~less than~~up to 3 feet in depth.
      d. For flow depths of greater than 3 feet ~~or more~~, covers must be designed by an Arizona registered civil engineer.
   3. The area taken up by the solid portion of the grates or louvers ~~is~~ must be subtracted from the total opening size so that only the total area open to flow is considered.

C. Smartvents™, USA Flood Air Vents, FloodFlaps® or other FEMA approved opening covers.

D. Other methods of covering flood openings may be used if supported by a report from an Arizona registered civil engineer.

VI. Documentation of Compliance

It is the responsibility of the registered professional completing the Elevation Certificate to accurately measure the number of flood openings and the total amount of space open to flow. This requirement includes calculating the area of the openings that are taken up by grates, louvers, etc. and are thus ineffective to flow.

A. Documentation of Openings with No Covers

If no flood opening covers are used the four required color photographs taken for the Elevation Certificate may be sufficient documentation of compliance provided that they clearly show all four sides of the structure and all of the flood openings are visible.

B. Documentation of Openings with Covers

If flood opening covers are used, in addition to the color photographs outlined in Section ~~6~~VI.A, ~~an~~ at least one additional color photograph shall be required that shows a close-up view of a typical opening. If more than one flood opening cover type is used, a color photograph of each type must be provided. The surveyor must state that the close-up photo is typical of all openings or of a specified number of the openings. The close-up photo(s) of the opening cover(s) may not be used as a substitute for ~~the~~ one of the four required photographs for the Elevation Certificate.

C. Documentation of Openings with Engineered Vents

If engineered flood vents are used, such as Smartvents™, USA Flood Air Vents, FloodFlaps® or other FEMA approved opening covers, the specification sheet for the specific model used shall be attached to the Elevation Certificate for the structure. If site-specific engineered vents are used, an As-Built certification from the engineer of record shall be attached to the Elevation Certificate for the structure.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 11/2/2009
Date(s) Revised: 11/2/15, 5/18/21

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO.: Technical Policy, TECH-024 **EFFECTIVE DATE:** May 18, 2021

POLICY NAME: Avoidance and Minimization Requirements When a Project Site Contains Regulated Riparian Habitat

PURPOSE: To clarify, Section 16.30.040.A.1 of the Floodplain Management Ordinance (Ordinance) that states a permit applicant shall provide "*Evidence that no reasonably practicable alternative exists to the proposed impact on mapped habitat and evidence that the impact has been minimized to the maximum extent practicable.*" This policy provides guidance on avoiding and minimizing impacts to mapped regulated riparian habitat (hereafter riparian habitat) during the planning, entitlement and permitting processes.

BACKGROUND:

The primary purpose of Chapter 16.30 of the Ordinance, entitled Watercourse and Riparian Habitat Protection and Mitigation Requirements, is to preserve natural floodplain functions. A functioning floodplain provides multiple benefits, including groundwater recharge, flood attenuation, erosion control, and improved surface water quality and ensures the long-term survival of native plants and wildlife dependent upon riparian habitat. These functions remain intact when riparian habitat along watercourses, floodplains, and areas of shallow groundwater are preserved and enhanced.

In 2005, the Flood Control District Board of Directors modified Chapter 16.30 and adopted the Riparian Classification Maps that designate regulated riparian habitat. The Ordinance requires that a property owner avoid and/or minimize disturbance to riparian habitat. This is accomplished when staff provides accurate information to the public during the site planning stage and works with either the property owner, applicant, developer, and/or consultant during the review of the development.

On May 19, 2015 the Board of Supervisors approved the Comprehensive Plan Update (hereafter Pima Prospers). Pima Prospers established a goal to require development to avoid floodplain and riparian habitat as shown on the included Regional Hydrology Maps, which consists of riparian habitat, FEMA and local floodplains. Specifically, Pima Prospers, Section 4.9 Flood Control and Drainage Element, Goal 1 Implementation Measures, a., states that the District shall "*Require, when appropriate, avoidance of development in Resource Areas as identified in the included Regional Hydrology Maps.*" This policy will identify when avoidance may be appropriate.

The District's goal in implementing this policy is to clarify what "no reasonable practicable alternative" means and ensure that design alternatives that avoid and/or minimize disturbance have been considered along with other factors before the disturbance of riparian habitat is allowed.

POLICY:

When a property or project site is impacted by riparian habitat, permit and entitlement applications are reviewed for avoidance of this habitat. Avoidance of disturbance to riparian habitat may require the applicant to be flexible during site design, and can be accomplished by coordinating with the District to identify alternate locations for the improvements, use of modified development standards, and/or use of sustainability features in site planning on a project site. While the Ordinance and Pima Prospers prioritize avoidance and minimization of disturbance to riparian habitat there will be situations when impacts to riparian habitat cannot be avoided. Land planning and development must balance various priorities including avoidance and minimization of disturbance of riparian habitat. Balancing those priorities can be best accomplished with site planning and reasonable flexibility by related interests. This policy provides guidance to help the Regional Flood Control District (District) staff, applicants, and the public consider what reasonably practicable avoidance and minimization means in order to provide consistent expectations to the regulated public and guidance for staff to provide consistent review criteria.

Riparian habitat classifications and/or boundaries may be adjusted per Technical Procedure TECH-104 prior to applying this policy.

DEFINITIONS:

The following definitions shall apply to this Technical Policy:

1. Disturbance is defined in Technical Policy TECH-004, Delineating Riparian Habitat Disturbances. The following are examples of riparian habitat disturbances:

    - Removal of native vegetation, including understory vegetation (small trees, shrubs, perennials, annuals, and grasses),
    - Removal or placement of soil,
    - Removal of woody debris, and other organic matter,
    - Human encroachments such as fencing, structures and placement of impervious surfaces (i.e.: pavement or sidewalks),
    - Parking of vehicles, or placement of other materials that disturbs existing grade.

2. Development Review refers to the review and permitting process of residential subdivisions and commercial development. This includes residential plats, land division for non-residential development and site permits.

3. Entitlement Review refers to the recommendation provided by District staff to the Development Services Department, Planning and Zoning Commission, Design Review Committee and/or Board of Supervisors for applicant requests to planning or zoning to change permissible yield and/or use of a property. This applies to comprehensive plan amendments, rezoning, variances, minor land division, lot splits, and plat note waivers.

4. Single lot development refers to improvements on individual parcels of land that typically goes through the building permit process, including structures, fencing and grading.

A. SINGLE LOT DEVELOPMENT:

Unless this policy was previously applied during the rezoning, entitlement or development review process for the subject property, when locating proposed and future improvement(s) on a single residential lot that contains riparian habitat, the following shall be considered and applied to the project:

1. Avoidance. When only a portion of a parcel or project site contains riparian habitat, the following shall be applied, unless adequately justified as outlined in Section F:
   a. Locate the improvement(s) outside the riparian habitat.
      i. In order to avoid riparian habitat, a request to reduce minimum setbacks for structures to property lines and/or distances between buildings can be made to the Development Services Zoning Administrator/Inspector. The modification shall be processed pursuant to Section 18.07.080 and no fee is applied to the request.
   b. Provide the location of a construction staging area on the site plan, when applicable. Locate the construction staging area outside of the riparian habitat or in an area that is already disturbed or will be disturbed by the improvement being permitted, such as a driveway.
   c. Plan ahead for future improvements and provide a buffer between the currently proposed improvement(s) and the riparian habitat to account for planned or unplanned future improvements.

2. Minimize. When the entire property is designated as riparian habitat, or if riparian habitat cannot be avoided, the following minimization techniques shall be applied, unless otherwise justified:
   a. Avoid existing drainage patterns or swales containing denser, more diverse vegetation.
   b. Avoid areas that provide riparian habitat connectivity to adjacent properties.
   c. Locate the improvement(s) on bare ground or existing disturbed areas.
   d. Avoid mature tree species, including those specific to riparian areas such as Fremont cottonwood, Arizona sycamore, and Arizona black walnut.
   e. When two classifications exist on a parcel, locate improvements within the lesser class habitat.
   f. Use elevation methods that create the least amount of disturbance. The preferred method of elevation is a stem wall foundation.
   g. Reduce the construction footprint, including driveway width and/or length of access from right of way, walled in patio areas and location of detached accessory structures to reduce pedestrian or vehicular circulation lengths.
   h. Place utilities in one location, or within a driveway or access easement.
   i. Locate the septic system to where it provides a buffer between site improvements and the riparian habitat.
   j. Minimization of disturbance includes preventing the introduction and spread of invasive species. To that end, invasive species control efforts shall include:
      i. Use on-site soils whenever possible.
      ii. When use of on-site soils is not possible, use of clean fill rather than top soil, which may have seeds of invasive species in it.
      iii. Cleaning mud off of construction vehicles prior to entering the site to reduce seed transmission.

B. DEVELOPMENT REVIEW PROJECTS:

Unless projects were subject to rezoning or other entitlement processes that utilized this policy, projects that are required to use the development review process shall follow the criteria listed below.

1. Avoidance. When only a portion of a parcel or project site contains riparian habitat, the following shall be applied, unless adequately justified as outlined in Section F:
   a. Locate building and construction envelopes outside of the riparian habitat. In order to avoid riparian habitat, minimum lot size requirements for subdivision lots may be modified pursuant to Section 18.07.080.
   b. Use modified development standards for parking pursuant to 18.07.080.
   c. Design drainage infrastructure to avoid riparian habitat and direct flows to enhance existing habitat.
   d. Locate the construction staging area outside of the riparian habitat.
   e. Pursuant to Pima County Zoning Code and Development Services policies, when riparian habitat is avoided and preserved, other mitigation requirements may be reduced.

2. Minimize. When the entire property is designated as riparian habitat, or if riparian habitat cannot be avoided, the following minimization techniques shall be applied, unless otherwise justified:
   a. Minimize construction footprint. Consolidate buildings, supporting site infrastructure and other impervious areas to reduce the building footprint to demonstrate all efforts are being made to avoid the riparian habitat.
   b. Locate improvements and construction envelopes in previously disturbed areas.
   c. When drainage infrastructure impacts riparian habitat it shall be designed to minimize the impact.
   d. When roads and utility crossings impact riparian habitat, locate the infrastructure perpendicular to riparian habitat corridors and where riparian corridors are the narrowest.
   e. When a proposed road crossing requires supporting drainage infrastructure that impacts riparian habitat, the road crossing shall be designed to minimize encroachment and allow for the movement of wildlife, such as dip crossings or concrete arch structures.
   f. Minimization of disturbance includes preventing the introduction and spread of invasive species. To that end, invasive species control efforts shall include:
      i. Use on-site soils whenever possible.
      ii. When use of on-site soils is not possible, use of clean fill rather than top soil, which may have seeds of invasive species in it.
      iii. Cleaning mud off of construction vehicles prior to entering the site to reduce seed transmission.

C. REZONING AND ENTITLEMENT PROJECTS:

Pima Prospers, Section 4.9 Flood Control and Drainage Element established Flood Control Resource Areas (hereafter Resource Areas) as shown on the Regional Hydrology Maps which requires, when appropriate, avoidance of development within these Resource Areas.

Projects that require development entitlements provide an opportunity through site planning to avoid the disturbance of riparian habitat. Requests that propose avoidance or minimize impacts to riparian habitat will be supported by the District.

1. Flexibility, including development clusters and modification of development standards shall be encouraged to reduce development footprints while achieving not less than minimum allowed yields and accommodate up to maximum permitted yields. The following methods can be used to reduce development footprints:
   a. Provide a reduction in building setbacks,
   b. Reduce residential lot size,
   c. Place functional square footage on multiple levels,
   d. Decrease road width and provide off-street parking, and
   e. Reduce parking lot size.
2. For Comprehensive Plan Amendment and rezoning requests received after the approval of this Technical Policy, when proposed development reduces water availability to riparian habitat, first flush and/or flow from proposed drainage infrastructure will supplement the water availability to the riparian habitat.
3. For Comprehensive Plan Amendment and rezoning requests received after the approval of this Technical Policy, when a project has riparian habitat that is denuded and the adjacent off-site upstream and/or downstream habitat is viable, the proposed drainage infrastructure will be designed to direct flow to the riparian habitat.
4. Road crossings shall be designed with only minor encroachment.
5. When avoidance is not possible and encroachment is proposed the District may recommend rezoning policies and/or conditions limiting encroachment and/or establishing mitigation criteria such as water supply design, plant density, size and species mix.

D. WAIVER OF THE SUBDIVISION PLAT REQUIREMENT OR A VARIANCE TO PIMA COUNTY CODE REQUIREMENTS:

1. Waiver and variance requests that result in an increased disturbance of riparian habitat will not be supported by the District. District staff will recommend denial or require special conditions during a hearing for any request that propose an increase of disturbance to riparian habitat.

E. TYPE II OR TYPE III CONDITIONAL USE PERMIT:

Requests to modify or expand the development potential of a site shall take the following criteria into account:

1. Requests for a Conditional Use Permit that result in an increased disturbance of riparian habitat will not be supported by the District. District staff will recommend denial or apply special conditions for any request that does not avoid or apply measures for minimizing impacts to riparian habitat.
2. When two classifications of riparian habitat impact a property and one type of classification is Important Riparian Areas (IRA), preservation of the IRA in a natural or undisturbed condition is preferred.
3. Road crossings and the extension of utilities which impact riparian habitat are the only disturbances that will be supported.

4. District staff will not support a request that disturbs more than 5% of riparian habitat classified as IRA.

F. JUSTIFICATION OF DISTURBANCE:

The following can be considered reasonable justifications for disturbing regulated riparian habitat. These justifications do not eliminate the requirement for mitigation when more than 1/3 of an acre of habitat is disturbed:

1. When the entire property is impacted by riparian habitat, disturbance will be supported when the natural floodplain function is preserved and encroachment in the following areas is avoided to the greatest extent practicable;
   a. floodplain and erosion hazard areas,
   b. densely vegetated areas,
   c. natural flow paths, and
   d. areas near riparian habitat corridors on adjacent properties.
2. Development proposals on parcels with more than one classification of habitat will be reviewed for opportunities to avoid and minimize disturbance of the higher classification of riparian habitat.
3. The purpose of the proposed improvement relative to existing improvements and uses. For example, a detached garage may be more appropriate to keep near a single-family residence than a barn.
4. New improvements that are placed within riparian habitat that was disturbed prior to the effective date of the Riparian Classification Maps if the area has remained disturbed and no habitat regrowth has occurred. This may apply to all or part of the historical disturbance area.
5. New redevelopment and infill projects that are placed within riparian habitat that was disturbed prior to the effective date of the Riparian Classification Maps, whether or not habitat regrowth has occurred, as these projects have the underlying goal of protecting undisturbed natural areas.
6. Placement of solar panels that require special site conditions to function, such as a particular orientation, sun exposure, etc.
7. Placement of a "low impact" improvement where the location is essential to the function of the improvement and the improvement is necessary to serve the project or property, such as a well site, in which placement within riparian habitat is unlikely to lead to additional improvements.
8. Establishing legal and physical access when the only access to the buildable area on a parcel cannot avoid the riparian habitat.
9. Grading and/or paving of physical access that crosses riparian habitat within a previously established access easement.
10. Site constraints, such as rock outcroppings, Hillside Development Zone (HDZ) restrictions, floodway, floodplain and erosion hazard setback limitations, cultural resource conflicts, or other site conditions that restrict placement of improvements.
11. Riparian habitat that lacks continuity ("islands" of riparian vegetation) and a natural source of water within urban and designated growth areas may be disturbed without demonstrating avoidance.
12. Improvements disturbing riparian habitat necessary for public safety do not require demonstration of avoidance. Examples include placement of road intersections to increase visibility, drainage improvements, or other public safety considerations.
13. Improvements located pursuant to a Section 404 Permit.
14. When the Total Vegetative Volume of the habitat is 0.5 m^3/m^2 or less and does not provide hydrologic connectivity to other riparian habitat areas.

G. IMPACTS LESS THAN 1/3 ACRE:

To ensure the purpose of the Ordinance and Pima Prospers is met, staff reviews projects for impacts to riparian habitat, regardless of the size of proposed disturbance. By reviewing development proposals, staff can assist applicants with site planning that avoids and/or minimizes impacts to riparian habitat, prevents the need for a riparian habitat mitigation plan, and ensures that floodplain function and riparian resources are preserved.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 5/18/21
Date(s) Revised: N/A

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO.: Technical Policy, TECH-024 **EFFECTIVE DATE:** May 18, 2021

POLICY NAME: Avoidance and Minimization Requirements When a Project Site Contains Regulated Riparian Habitat

PURPOSE: To clarify, Section 16.30.040.A.1 of the Floodplain Management Ordinance (Ordinance) that states a permit applicant shall provide "*Evidence that no reasonably practicable alternative exists to the proposed impact on mapped habitat and evidence that the impact has been minimized to the maximum extent practicable.*" This policy provides guidance on avoiding and minimizing impacts to mapped regulated riparian habitat (hereafter riparian habitat) during the planning, entitlement and permitting processes.

BACKGROUND:

The primary purpose of Chapter 16.30 of the Ordinance, entitled Watercourse and Riparian Habitat Protection and Mitigation Requirements, is to preserve natural floodplain functions. A functioning floodplain provides multiple benefits, including groundwater recharge, flood attenuation, erosion control, and improved surface water quality and ensures the long-term survival of native plants and wildlife dependent upon riparian habitat. These functions remain intact when riparian habitat along watercourses, floodplains, and areas of shallow groundwater are preserved and enhanced.

In 2005, the Flood Control District Board of Directors modified Chapter 16.30 and adopted the Riparian Classification Maps that designate regulated riparian habitat. The Ordinance requires that a property owner avoid and/or minimize disturbance to riparian habitat. This is accomplished when staff provides accurate information to the public during the site planning stage and works with either the property owner, applicant, developer, and/or consultant during the review of the development.

On May 19, 2015 the Board of Supervisors approved the Comprehensive Plan Update (hereafter Pima Prospers). Pima Prospers established a goal to require development to avoid floodplain and riparian habitat as shown on the included Regional Hydrology Maps, which consists of riparian habitat, FEMA and local floodplains. Specifically, Pima Prospers, Section 4.9 Flood Control and Drainage Element, Goal 1 Implementation Measures, a., states that the District shall "*Require, when appropriate, avoidance of development in Resource Areas as identified in the included Regional Hydrology Maps.*" This policy will identify when avoidance ~~is~~ may be appropriate.

The District's goal in implementing this policy is to clarify what "no reasonable practicable alternative" means and ensure that design alternatives that avoid and/or minimize disturbance have been considered along with other factors before the disturbance of riparian habitat is allowed.

POLICY:

When a property or project site is impacted by riparian habitat, permit and entitlement applications are reviewed for avoidance of this habitat. Avoidance of disturbance to riparian habitat may require the

applicant to be flexible during site design, and can be accomplished by coordinating with the District to identify alternate locations for the improvements, use of modified development standards, and/or use of sustainability features in site planning on a project site. While the Ordinance and Pima Prospers prioritize avoidance and minimization of disturbance to riparian habitat there will be situations when impacts to riparian habitat cannot be avoided. Land planning and development must balance various priorities including avoidance and minimization of disturbance of riparian habitat. Balancing those priorities can be best accomplished with site planning and reasonable flexibility by related interests. This policy provides guidance to help the Regional Flood Control District (District) staff, applicants, and the public consider what reasonably practicable~~apply rules of~~ avoidance and minimization ~~consistently~~means in order to provide consistent expectations to the regulated public and guidance for staff to provide consistent review criteria.

Riparian habitat classifications and/or boundaries may be adjusted per Technical Procedure TECH-104 prior to applying this policy.

DEFINITIONS:

The following definitions shall apply to this Technical Policy:

1. Disturbance is defined in Technical Policy TECH-004, Delineating Riparian Habitat Disturbances. The following are examples of riparian habitat disturbances:

    - Removal of native vegetation, including understory vegetation (small trees, shrubs, perennials, annuals, and grasses),
    - Removal or placement of soil,
    - Removal of woody debris, and other organic matter,
    - Human encroachments such as fencing, structures and placement of impervious surfaces (i.e.: pavement or sidewalks),
    - Parking of vehicles, or placement of other materials that disturbs existing grade.

2. Development Review refers to the review and permitting process of residential subdivisions and commercial development. This includes residential plats, land division for non-residential development and site permits.

3. ~~3.~~ Entitlement Review refers to the recommendation provided by District staff to the Development Services Department, Planning and Zoning Commission, Design Review Committee and/or Board of Supervisors for applicant requests to planning or zoning to change permissible yield and/or use of a property. This ~~includes~~ applies to comprehensive plan amendments, rezoning, ~~rezoning time extensions, and modification of rezoning conditions, specific plans,~~ variances, minor land division, lot splits, and plat note waivers.

~~3.~~4. Single lot development refers to improvements on individual parcels of land that typically goes through the building permit process, including structures, fencing and grading.

A. SINGLE LOT DEVELOPMENT:

Unless this policy was previously applied during the rezoning, entitlement or development review process for the subject property, ~~W~~when locating proposed and future improvement(s) on a single residential lot that contains riparian habitat, the following shall be considered and applied to the project:

1. Avoidance. When only a portion of a parcel or project site contains riparian habitat, the following shall be applied, unless adequately justified as outlined in ~~Paragraph~~ Section F:
   a. Locate the improvement(s) outside the riparian habitat.
      i. In order to avoid riparian habitat, a request to reduce minimum setbacks for structures to property lines and/or distances between buildings can be made to the Development Services Zoning Administrator/Inspector. The modification shall be processed pursuant to Section 18.07.080 and no fee is applied to the request.
   b. Provide the location of a construction staging area on the site plan, when applicable. Locate the construction staging area outside of the riparian habitat or in an area that is already disturbed or will be disturbed by the improvement being permitted, such as a driveway.
   c. Plan ahead for future improvements and provide a buffer between the currently proposed improvement(s) and the riparian habitat to account for planned or unplanned future improvements.

2. Minimize. When the entire property is designated as riparian habitat, or if riparian habitat cannot be avoided, the following minimization techniques shall be applied, unless otherwise justified:
   a. Avoid existing drainage patterns or swales containing denser, more diverse vegetation.
   b. Avoid areas that provide riparian habitat connectivity to adjacent properties.
   c. Locate the improvement(s) on bare ground or existing disturbed areas.
   d. Avoid mature tree species, including those specific to riparian areas such as Fremont cottonwood, Arizona sycamore, and Arizona black walnut.
   e. When two classifications exist on a parcel, locate improvements within the lesser class habitat.
   f. Use elevation methods that create the least amount of disturbance. The preferred method of elevation is a stem wall foundation.
   g. Reduce the construction footprint, including driveway width and/or length of access from right of way, walled in patio areas and location of detached accessory structures to reduce pedestrian or vehicular circulation lengths.
   h. Place utilities in one location, or within a driveway or access easement.
   i. Locate the septic system to where it provides a buffer between site improvements and the riparian habitat.
   j. Minimization of disturbance includes preventing the introduction and spread of invasive species. To that end, invasive species control efforts shall include:
      i. Use on-site soils whenever possible.
      ii. When use of on-site soils is not possible, use of clean fill rather than top soil, which may have seeds of invasive species in it.
      ~~i.~~iii. Cleaning mud off of construction vehicles prior to entering the site to reduce seed transmission.

B. DEVELOPMENT REVIEW PROJECTS:

Unless projects were subject to rezoning or other entitlement processes that utilized this policy, ~~P~~projects that are required to use the development review process shall follow the criteria listed below.

~~This criteria is in addition to the requirements and development conditions from previous approvals such as, a conditional use permit, rezoning, specific plan or comprehensive plan amendment.~~

1. Avoidance. When only a portion of a parcel or project site contains riparian habitat, the following shall be applied, unless adequately justified as outlined in ~~Paragraph~~ Section F:
   ~~a.~~ Locate building and construction envelopes outside of the riparian habitat. In order to avoid riparian habitat, minimum lot size requirements for subdivision lots ~~in the CR-1, CR-2, CR-3, GR-1 and CMH-1 zones~~ may be modified ~~at the time of plat approval using~~pursuant to Section 18.07.080. ~~Below is the list of potential reduction;~~
   ~~b. Minimum lot size requirements for lots in a CR-1 or GR-1 subdivision may be reduced from thirty-six thousand square feet to eighteen thousand square feet;~~
   ~~c. Minimum lot size requirements for lots in a CR-2 subdivision may be reduced from sixteen thousand square feet to twelve thousand square feet;~~
   ~~d.~~a. ~~Minimum lot size requirements for lots in a CR-3 or CMH-1 subdivision may be reduced from eight thousand square feet to seven thousand square feet.~~
   ~~e.~~b. Use modified development standards for parking ~~. P~~pursuant to 18.07.080~~, when it is demonstrated a change to the off-street parking requirements does not result in a danger to the public or property, or result in an increased traffic volume, the subdivision and development review committee can approve a modification that allows for avoidance to riparian habitat~~.
   ~~f.~~c. Design drainage infrastructure to avoid riparian habitat and direct flows to enhance existing habitat.
   ~~g.~~d. Locate the construction staging area outside of the riparian habitat.
   ~~h.~~e. Pursuant to ~~Section 18.07.080~~Pima County Zoning Code and Development Services policies, when riparian habitat is avoided and preserved ~~the number of trees required in bufferyards may be reduced~~, other mitigation requirements may be reduced.

2. Minimize. When the entire property is designated as riparian habitat, or if riparian habitat cannot be avoided, the following minimization techniques shall be applied, unless otherwise justified:
   a. Minimize construction footprint. Consolidate buildings, supporting site infrastructure and other impervious areas to reduce the building footprint to demonstrate all efforts are being made to avoid the riparian habitat.
   b. Locate improvements and construction envelopes in previously disturbed areas.
   c. When drainage infrastructure impacts riparian habitat it shall be designed to minimize the impact.
   d. When roads and utility crossings impact riparian habitat, locate the infrastructure perpendicular to riparian habitat corridors and where riparian corridors are the narrowest.
   e. When a proposed road crossing requires supporting drainage infrastructure that impacts riparian habitat, the road crossing shall be designed to minimize encroachment and allow for the movement of wildlife, such as dip crossings or concrete arch structures.
   f. Minimization of disturbance includes preventing the introduction and spread of invasive species. To that end, invasive species control efforts shall include:
      i. Use on-site soils whenever possible.
      ii. When use of on-site soils is not possible, use of clean fill rather than top soil, which may have seeds of invasive species in it.
      ~~i.~~iii. Cleaning mud off of construction vehicles prior to entering the site to reduce seed transmission.

C. ~~DEVELOPMENT~~ REZONING AND ENTITLEMENT PROJECTS:

Pima Prospers, Section 4.9 Flood Control and Drainage Element established Flood Control Resource Areas (hereafter Resource Areas) as shown on the Regional Hydrology Maps which requires, when appropriate, avoidance of development within these Resource Areas.

Projects that require development entitlements provide an opportunity through site planning to avoid the disturbance of riparian habitat. Requests that propose avoidance or minimize impacts to riparian habitat will be supported by the District.

1. ~~D~~Flexibility, including development clusters and modification of development standards shall be encouraged to reduce development footprints while achieving not less than minimum ~~required~~ allowed yields and accommodate up to maximum permitted yields. The following methods can be used to reduce development footprints:
   a. Provide a reduction in building setbacks,
   b. Reduce residential lot size,
   c. Place functional square footage on multiple levels,
   d. Decrease road width and provide off-street parking, and
   e. Reduce parking lot size.
2. For Comprehensive Plan Amendment and rezoning requests received after the approval of this Technical Policy, ~~W~~when proposed development reduces water availability to riparian habitat, first flush and/or flow from proposed drainage infrastructure will supplement the water availability to the riparian habitat.
3. For Comprehensive Plan Amendment and rezoning requests received after the approval of this Technical Policy, ~~W~~when a project has riparian habitat that is denuded and the adjacent off-site upstream and/or downstream habitat is viable, the proposed drainage infrastructure will be designed to direct flow to the riparian habitat.
4. Road crossings shall be designed with only minor encroachment.
5. When avoidance is not possible and encroachment is proposed the District may recommend rezoning policies and/or conditions limiting encroachment and/or establishing mitigation criteria such as water supply design, plant density, size and species mix.

D. WAIVER OF THE SUBDIVISION PLAT REQUIREMENT OR A VARIANCE TO PIMA COUNTY CODE REQUIREMENTS:

1. Waiver and variance requests that result in an increased disturbance of riparian habitat will not be supported by the District. District staff will recommend denial or require special conditions during a hearing for any request that propose an increase of disturbance to riparian habitat.
2. ~~Waiver and variance requests that propose avoidance or minimize impacts to riparian habitat will be supported by the District.~~

E. TYPE II OR TYPE III CONDITIONAL USE PERMIT:

Requests to modify or expand the development potential of a site shall take the following criteria into account:

1. Requests for a Conditional Use Permit that result in an increased disturbance of riparian habitat will not be supported by the District. District staff will recommend denial or apply special conditions for any request that does not avoid or apply measures for minimizing impacts to riparian habitat.
2. When two classifications of riparian habitat impact a property and one type of classification is Important Riparian Areas (IRA), preservation of the IRA in a natural or undisturbed condition is preferred.
3. Road crossings and the extension of utilities which impact riparian habitat are the only disturbances that will be supported.
4. District staff will not support a request that disturbs more than 5% of riparian habitat classified as IRA.

F. JUSTIFICATION OF DISTURBANCE:

The following can be considered reasonable justifications for disturbing regulated riparian habitat. These justifications do not eliminate the requirement for mitigation when more than 1/3 of an acre of habitat is disturbed: ~~The following do not eliminate any requirements for mitigation of riparian habitat disturbance, but can be considered reasonable justification for disturbance:~~

1. When the entire property is impacted by riparian habitat, disturbance will be supported when the natural floodplain function is preserved and encroachment in the following areas ~~are~~ is avoided to the greatest extent practicable;
   a. floodplain and erosion hazard areas,
   b. densely vegetated areas,
   c. natural flow paths, and
   d. areas near riparian habitat corridors on adjacent properties.
2. Development proposals on parcels with more than one classification of habitat will be reviewed for opportunities to avoid and minimize disturbance of the higher classification of riparian habitat.
3. The purpose of the proposed improvement relative to existing improvements and uses. For example, a detached garage may be more appropriate to keep near a single-family residence than a barn.

   ~~3. The proposed improvement's function should be considered when assessing its location on the property. For example, an addition to an existing structure that is within riparian habitat is an allowable disturbance since it must be located adjacent to the existing development. However, a detached structure, such as barn or shed, does not need to be placed adjacent to the primary structure unless it is sufficiently demonstrated that riparian habitat avoidance would effectively preclude the intended use of the structure.~~
4. New improvements ~~may be~~ that are placed within riparian habitat that was disturbed prior to the effective date of the Riparian Classification Maps if the area has remained disturbed and no habitat regrowth has occurred. This may apply to all or part of the historical disturbance area. ~~been in continual use since the time of disturbance.~~
5. ~~Riparian habitat that has had historical disturbance prior to the mapping.~~
~~5.~~6. New redevelopment and infill projects that are placed within riparian habitat that was disturbed prior to the effective date of the Riparian Classification Maps, whether or not habitat regrowth has occurred, as these projects have the underlying goal of protecting undisturbed natural areas.
~~6.~~7. Placement of solar panels that require special site conditions to function, such as a particular orientation, ~~shading~~sun exposure, etc.

~~7.~~8. Placement of a "low impact" improvement where the location is essential to the function of the improvement and the improvement is necessary to serve the project or property, such as a well site, in which placement within riparian habitat is unlikely to lead to additional improvements.

~~8.~~9. Establishing legal and physical access when the only access to the buildable area on a parcel cannot avoid the riparian habitat. ~~When buildable areas exist where access can avoid disturbing the riparian habitat, that area should be utilized first.~~

~~9.~~10. Grading and/or paving of physical access that crosses riparian habitat within a previously established access easement.

~~10.~~11. Site constraints, such as rock outcroppings, Hillside Development Zone (HDZ) restrictions, floodway, floodplain and erosion hazard setback limitations, cultural resource conflicts, or other site conditions that restrict placement of improvements.

~~11.~~12. Riparian habitat that lacks continuity ("islands" of riparian vegetation) and a natural source of water within urban and designated growth areas may be disturbed without demonstrating avoidance ~~on a case by case basis~~.

13. Improvements disturbing riparian habitat necessary for public safety do not require demonstration of avoidance. Examples include placement of road intersections to increase visibility, drainage improvements, or other public safety considerations.

14. Improvements located pursuant to a Section 404 Permit.

~~12.~~15. When the Total Vegetative Volume of the habitat is 0.5 m^3/m^2 or less and does not provide hydrologic connectivity to other riparian habitat areas.

~~An applicant's personal preference, aesthetic reasons, financial hardship, lot yield, or conflicts with other non-public safety requirements are not reasonable justifications for disturbance.~~

G. IMPACTS LESS THAN 1/3 ACRE:

To ensure the purpose of the Ordinance and Pima Prospers is met, staff reviews projects for impacts to riparian habitat, regardless of the size of proposed disturbance. By reviewing development proposals, staff can assist applicants with site planning that avoids and/or minimizes impacts to riparian habitat, prevents the need for a riparian habitat mitigation plan, and ensures that floodplain function and riparian resources are preserved.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 5/18/21
Date(s) Revised: N/A

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO.: Technical Policy, TECH-026 **EFFECTIVE DATE: May 18, 2021**
REVISED: N/A

POLICY TITLE: Regulation of Single-Lot Development within Flow Corridors

PURPOSE:
The purpose of this policy is to establish guidelines for permitting development within Flow Corridors.

BACKGROUND:
Flow Corridors are a regulatory concept first established in 1999 with the delineation of the flow corridors in the Brawley Wash area. These flow corridors were identified in order to establish continuous flow paths for the most hazardous areas within the large, distributary Brawley Wash floodplain. This concept was more fully considered during the development of the Lee Moore Wash Basin Management Plan (May 17, 2011), which established Development Criteria for the flow corridors delineated in that study. Flow Corridors are the primary flow paths within the floodplain where sheet flow or braided or distributary flow regimes are present. Flow Corridors are intended to serve as the designated floodplain for regional drainage, when land use planning. Maintaining the efficient conveyance of flood water downstream through Flow Corridors is important for maintaining flood storage capacity and the natural functions of the floodplain.

Within Flow Corridors, flow depths and velocities are expected to be greater and flow paths will often be variable and uncertain, creating hazardous conditions that may change over relatively short time periods, possibly during the course of a single flow event. Less restrictive than Administrative Floodways, the purpose of establishing Flow Corridors is to provide a tool to regulate development within and direct development away from these high hazard areas.

POLICY:

Due to the more hazardous flood conditions within Flow Corridors, greater caution is necessary when development is proposed. As such, in order to ensure public safety, this policy establishes development standards within Flow Corridors.

For the purpose of this policy, braided or distributary flow shall be defined as any area where there are multiple channels across the cross-section of the flow corridor. A channel will generally be considered to be a low-lying flow area with a sandy bottom that may or may not have a defined bank, but which is an area of more frequent flow than the surrounding land.

I. Conditions Applicable to Any Single Lot Development

The following policies shall apply to any development on a parcel impacted by a Flow Corridor:

A. Avoidance

1. For properties that are not entirely within a Flow Corridor, any new development shall be located entirely outside of the Flow Corridor unless there is insufficient space outside the Flow Corridor or other limiting factors necessitates placing the development within the Flow Corridor.
2. For any development placed wholly or partially within a Flow Corridor, the development shall be placed in the least hazardous area within the Flow Corridor.

B. Exceptions

The following developments are not subject to this Policy. This does not exempt these developments from requiring permits or from any other rule, regulation or policy:

1. Open fencing as defined in Technical Policy TECH-005.
2. Septic system, provided:
    a. it is located in an area where the associated structure can be located outside of the Flow Corridor, and
    b. it is not within an erosion hazard area unless supported by an engineering analysis completed by an Arizona registered civil engineer which has been reviewed and approved by the District.
3. Unimproved driveways that cross washes at-grade.
4. Open-sided shade structures.

In addition to the exceptions above, permitting flexibility will be allowed for improvements that are functionally dependent upon existing improvements, such as the construction of a detached garage on a property with an existing residence. In these types of cases, the District may relax the requirements of this Policy that go above and beyond the requirements of other rules or policies.

C. Drainage Analysis

The following criteria must be considered for development within a Flow Corridor.

1. Development in braided or distributary flow areas shall not concentrate flows or eliminate flow paths that change the flow rate or flow distribution on adjacent parcels.
2. For drainage infrastructure design and erosion hazard setback purposes, if a hydraulic rating is used to determine flow distribution at a flow-split, at least 50% of the base flood discharge upstream of the flow split shall be applied on any single channel downstream of the split unless a publicly maintained engineered structure controls the flow distribution. If no hydraulic modeling is provided, the full base flood discharge upstream of the flow split shall be applied on each downstream channel.
3. An analysis of the drainage must include a review of historical aerial photographs in order to determine whether the proposed development is located within an historic flow path. If historic flow paths impact the development, the drainage analysis shall:
    a. demonstrate that a return to that flow path is restricted by a publicly maintained engineered structure that controls flow distribution, or by natural, durable changes within the watershed, or
    b. require an engineered design to protect the development from the hazard, assuming flow returns to the historic flow path.
4. The District may require that the evaluation of the above criteria be completed by an Arizona registered civil engineer. An analysis is required under the following conditions:
    a. flow depths within the area of concern (see Section II) are 2 feet or more, or
    b. more than 25% of the width of the flow corridor will be obstructed by the development, or
    c. other conditions or hazards exist that warrant analysis, as determined by the District.

II. Conditions Applicable to Structures

The placement of structures within floodplains represents placing lives and property at risk. Since Flow Corridors are areas of higher risk, every effort must be made to locate structures outside of Flow Corridors. When relocation is not an option, extra design considerations are warranted to ensure that construction accounts for current and foreseeable future conditions within the Flow Corridor.

A habitable structure is any structure that is used for purposes other than vehicle parking and limited storage. Habitable structures include site-built homes, manufactured homes, guest houses, studios, workshops, etc.

A. Requirements for Structures Within Flow Corridors

1. When the flow corridor is subject to braided or distributary flow, it must be assumed that flow conditions at the location of the proposed structure will change over time. Therefore flow depths and velocities at the site may increase. When determining the appropriate Base Flood Elevation (BFE) and erosion protection measures for a structure, the more restrictive of the following criteria shall be used unless an alternative is justified by an engineering analysis:
    a. a minimum BFE of at least 0.5 feet regardless of current flood conditions, or
    b. the most restrictive flow conditions (BFE and velocity) within 50 feet of any habitable structure and 25 feet of any non-habitable structure.
2. Any structure, including any fill pad associated with the structure, shall not be placed on existing or historic channels or flow paths unless an engineering report submitted to and approved by the District:
    a. demonstrates that the proposed location is the least hazardous location on the parcel, and
    b. provides a foundation design using the analysis criteria in I.C.

III. Fences and Walls

Fences and walls have the potential to significantly alter or obstruct flow, and are discouraged within Flow Corridors. Whenever fences/walls are proposed within a Flow Corridor, open type fences, as defined by Technical Policy TECH-005, are the preferred option.

Except as noted in this policy, fences and walls shall be constructed pursuant to the standards of Technical Policy TECH-005. Application of the requirements below is at the discretion of the District based upon site-specific conditions.

A. Open Fences

Open fences shall be constructed pursuant to the standards of Technical Policy 005.

B. Woven Wire and Wrought Iron Fences

The following additional criteria apply to woven wire fences within Flow Corridors:

1. In all cases, woven wire and wrought iron fences shall be elevated at or above the Base Flood Elevation, unless:
    a. the fence is less than 50% of the width of the property perpendicular to flow (property line setback requirements from Technical Policy TECH-005 still apply), and/or
    b. the fence encloses a small portion of the parcel for the purpose of:
        i. enclosing a swimming pool, or
        ii. providing a small enclosure for pets or personal use.
2. When spanning regulatory washes, woven wire fences must be elevated at or above the Regulatory Flood Elevation as measured at the top of the banks of the channel.
3. Individual strands of wire may be placed horizontally below the bottom of the fence at six inch intervals per Technical Policy 005.

C. Solid Fences and Walls

The following additional criteria apply to walls and solid fences within Flow Corridors.

1. Walls and non-elevated solid fences are prohibited, unless.
    a. the wall/fence is located entirely upon an approved fill pad, or

b. an engineering report prepared by an Arizona registered civil engineer demonstrates that wall/fence will not adversely impact any adjacent parcel under intact and failed conditions, or
c. the purpose of the wall/fence is to enclose a swimming pool and the wall/fence is;
    i. at least 50 feet from any property boundary, OR
    ii. located immediately upstream or downstream of the principle dwelling unit and,
    iii. located at least 25 feet from the upstream property boundary, and
    iv. the wall/fence does not create more than 25 feet of additional encroachment as measured perpendicular to the direction of flow.

2. In lieu of C.1.a through C.1.c above, solid fences may be elevated at or above the Regulatory Flood Elevation.
3. Individual strands of wire may be placed below the bottom of the fence/wall at six inch intervals per Technical Policy 005

IV. Access and Utilities

Since flows within Flow Corridors are expected to be both more frequent and more hazardous, use of Flow Corridors for property access increases the risk of harm and lack of access to/from the property by residents and emergency response personnel and is therefore discouraged.

Driveway/Roadway crossings within Flow Corridors may also create considerable maintenance and safety issues if not properly designed, constructed, and maintained. These problems include sediment-transport disruption, increased flow velocities and scour downstream of the crossing, ponding and flow diversion upstream of the crossing, unintended overtopping of the roadway due to debris clogging of culverts and erosion of channel banks adjoining the crossing. Crossings that utilize the natural main-channel depth, width, and slope at the crossing location will have the least impact and are therefore recommended.

Similarly, placement of utilities within Flow Corridors can present safety hazards, and improper design of utility crossings could lead to disruption of service and create additional safety hazards due to damage.

A. Access Crossings

The following standards apply to driveway and roadway crossings (hereafter, access crossings).

1. Access crossings are discouraged at locations where the watercourse is braided. Where braided watercourses must be crossed, crossings that minimize flow contraction and disruption of sediment balance are recommended.
    a. Unimproved access crossings are recommended.
    b. Improved access crossings shall be designed per Technical Policy 027.
2. Access crossings shall be designed so the roadway alignment is perpendicular to the watercourse in order to minimize disruption to the floodplain. Exceptions may be made due to site constraints such as easements, on a case by case basis.
3. Access crossings shall generally be located:
    a. at the narrowest part of the floodplain, or
    b. where there are the least number of braids to be crossed.
4. Approval of the access crossing or the development necessitating the crossing may be conditional upon inspection of the construction of the crossing during or after construction.

B. Utility Crossings

The following guidelines apply to utility crossings.

1. Utilities shall be buried below the total 100-year scour depth in the main channel(s), including any long-term scour component (i.e., streambed degradation), unless acceptable engineering mitigation is provided;

2. Where the potential for lateral migration of the main channel(s) exists, underground utilities shall be buried at the same elevation in the overbank areas or erosion-hazard area as in the main channel, unless controls are in place to prevent utility damage and/or exposure after lateral movement of the main channel;
3. When practical, utilities shall cross at the same location and in the same manner as access crossings, and be:
    a. located on the upstream side of the culvert or at-grade crossing unless placement at the downstream location is justified, or
    b. incorporated into the design of improved crossings;
4. After construction, utility crossings not associated with an access crossing shall be revegetated in a manner consistent with all applicable local, state, and federal laws and regulations. U.S. Army Corps of Engineers 404 Permit requirements typically provide guidance for this activity.
5. Utility crossings that are not co-located with access crossings shall generally be located:
    a. at the narrowest part of the floodplain, or
    b. where the least number of braids will be crossed.
6. Approval of the utility crossing or the development necessitating the crossing may be conditional upon inspection of the burial depth of the utilities and/or constructed development protecting the utilities. Inspections may be conducted by the District and/or other agencies.

V. Historical Flow Corridors and Corridor Equivalents

There are several Flow Corridors or equivalents that were established prior to this Policy with specific requirements that differ from this Policy. The treatment of each of these Flow Corridors and equivalents is established below. Any Flow Corridor not specifically referenced below is subject to the requirements above in full.

A. Black Wash Administrative Floodway

The Black Wash Administrative Floodway was established by Floodplain Study #15, *Black Wash Drainage Analysis and Policy Assessment Report*, dated 9/12/1990. As a result of this study, the Black Wash Administrative Floodway has been regulated under the floodway provisions of the Floodplain Management Ordinance. The Black Wash Administrative Floodway shall continue to be regulated in this manner.

B. Brawley Wash Corridor

The Brawley Wash Corridor was established by Floodplain Study #42, titled *Brawley Wash Primary Flood Corridor Study*, by Simons, Li & Associates dated 6/1/1999. By at least 9/27/2002, per a memorandum by Barbara L. Johnson, P.E., Manager, an engineering study was required for development within the Brawley Wash Primary Flood Corridor (hereafter Brawley Wash Corridor) established by Floodplain Study #42. This was preceded by a history of denying permits within the Brawley Wash that predated even the mapping of the Brawley Wash Corridor, according a memorandum from Director Antonio C. Paez dated 6/2/1995.

In practice, the engineering requirement within the Brawley Wash Corridor has only applied to the construction or placement of structures within the corridor. As such:

1. For the construction of structures, including the placement of manufactured homes, within the corridor, an engineering analysis shall be required that, at minimum,
    a. assesses the flood conditions on the property,
    b. determines the potential scour depth at the location of the proposed structure, and
    c. designs a foundation that protects the structure from erosion and scour.
2. For all other types of development, the provisions of this Policy shall apply to the Brawley Wash Corridor.

C. Lee Moore Wash Basin Management Study Flow Corridor

The Lee Moore Wash Flow Corridors were created by Floodplain Study #10 in 2009, which was an update of an earlier floodplain study for the Lee Moore Wash basin. The Flow Corridors established for the Lee Moore

Wash Basin were created largely to guide new commercial and multi-lot subdivision development. Subsequent restudy of the Lee Moore Wash watershed was completed in 2019. The 2019 study also delineated Flow Corridors. This report was not intended to guide single-lot development. As such:

1. For commercial and subdivision development the rules established by the 2009 report *Implementation Plan and Development Criteria for the Lee Moore Wash Basin Management Plan* shall apply. Namely,
    a. Flow Corridors are to be left in their natural condition, and
    b. Flow Corridors are to be left undeveloped and unimpeded.
2. For single-lot development, the provisions of this Policy shall apply to Flow Corridors using the 2018 and 2019 Flow Corridor delineations.

D. Tortolita Spine Wash

The Tortolita Fan Spine Washes were established by Floodplain Study #24, titled *Tortolita Area Basin Management Plan*, by Cella Barr Associates dated 8/3/1993. By at least 9/27/2002, per a memorandum by Barbara L. Johnson, P.E., Manager, an engineering study was required within these Spine Washes. In practice, the engineering requirement within Spine Washes has only applied to the construction or placement of structures within the Spine Washes. However, recent and more robust floodplain studies within the Tortolita Fan indicate that an engineering analysis isn't always warranted. As such:

1. For the construction of structures, including the placement of manufactured homes, within the mapped spine washes, staff shall determine whether an engineering analysis is required on a case-by-case basis. When required, the engineering analysis shall, at minimum,
    a. assess the flood conditions on the property,
    b. determine the potential scour depth at the location of the proposed structure, and
    c. design a foundation that protects the structure from erosion and scour.
2. When an engineering analysis is not required for structures, and for all other types of development, the provisions of this Policy shall apply to development within the Tortolita Spine Washes.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 5/18/21
Date(s) Revised: N/A

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NO.: Technical Policy, TECH-026 **EFFECTIVE DATE: May 18, 2021**
REVISED: N/A

POLICY TITLE: Regulation of Single-Lot Development within Flow Corridors

PURPOSE:
The purpose of this policy is to establish guidelines for permitting development within Flow Corridors.

BACKGROUND:
Flow Corridors are a regulatory concept first established in 1999 with the delineation of the flow corridors in the Brawley Wash area. These flow corridors were identified in order to establish continuous flow paths for the most hazardous areas within the large, distributary Brawley Wash floodplain. This concept was more fully considered during the development of the Lee Moore Wash Basin Management Plan (May 17, 2011), which established Development Criteria for the flow corridors delineated in that study. Flow Corridors are the primary flow paths within the floodplain where sheet flow or braided or distributary flow regimes are present. Flow Corridors are intended to serve as the designated floodplain for regional drainage, when land use planning. Maintaining the efficient conveyance of flood water downstream through Flow Corridors is important for maintaining flood storage capacity and the natural functions of the floodplain.

Within Flow Corridors, flow depths and velocities are expected to be greater and flow paths will often be variable and uncertain, creating hazardous conditions that may change over relatively short time periods, possibly during the course of a single flow event. Less restrictive than Administrative Floodways, the purpose of establishing Flow Corridors is to provide a tool to regulate development within and direct development away from these high hazard areas.

POLICY:

Due to the more hazardous flood conditions within Flow Corridors, greater caution is necessary when development is proposed. As such, in order to ensure public safety, this policy establishes development standards within Flow Corridors.

For the purpose of this policy, braided or distributary flow shall be defined as any area where there are multiple channels across the cross-section of the flow corridor. A channel will generally be considered to be a low-lying flow area with a sandy bottom that may or may not have a defined bank, but which is an area of more frequent flow than the surrounding land.

I. Conditions Applicable to Any Single Lot Development

The following policies shall apply to any development on a parcel impacted by a Flow Corridor:

A. Avoidance

1. For properties that are not entirely within a Flow Corridor, any new development shall be located entirely outside of the Flow Corridor unless there is insufficient space outside the Flow Corridor or other limiting factors necessitates placing the development within the Flow Corridor.
2. For any development placed wholly or partially within a Flow Corridor, the development shall be placed in the least hazardous area within the Flow Corridor.

B. Exceptions

The following developments are not subject to this Policy. This does not exempt these developments from requiring permits or from any other rule, regulation or policy:

1. Open fencing as defined in Technical Policy TECH-005.
2. Septic system, provided:
    a. it is located in an area where the associated structure can be located outside of the Flow Corridor, and
    b. it is not within an erosion hazard area unless supported by an engineering analysis completed by an Arizona registered civil engineer which has been reviewed and approved by the District.
3. Unimproved driveways that cross washes at-grade.
4. Open-sided shade structures.

In addition to the exceptions above, permitting flexibility will be allowed for improvements that are functionally dependent upon existing improvements, such as the construction of a detached garage on a property with an existing residence. In these types of cases, the District may relax the requirements of this Policy that go above and beyond the requirements of other rules or policies.

C. Drainage Analysis

The following criteria must be considered for development within a Flow Corridor.

1. Development in braided or distributary flow areas shall not concentrate flows or eliminate flow paths that change the flow rate or flow distribution on adjacent parcels.
2. For drainage infrastructure design and erosion hazard setback purposes, if a hydraulic rating is used to determine flow distribution at a flow-split, at least 50% of the base flood discharge upstream of the flow split shall be applied on any single channel downstream of the split unless a publicly maintained engineered structure controls the flow distribution. If no hydraulic modeling is provided, the full base flood discharge upstream of the flow split shall be applied on each downstream channel.
3. An analysis of the drainage must include a review of historical aerial photographs in order to determine whether the proposed development is located within an historic flow path. If historic flow paths impact the development, the drainage analysis shall:
    a. demonstrate that a return to that flow path is restricted by a publicly maintained engineered structure that controls flow distribution, or by natural, durable changes within the watershed, or
    b. require an engineered design to protect the development from the hazard, assuming flow returns to the historic flow path.
4. The District may require that the evaluation of the above criteria be completed by an Arizona registered civil engineer. An analysis is required under the following conditions:
    a. flow depths within the area of concern (see Section II) are 2 feet or more, or
    b. more than 25% of the width of the flow corridor will be obstructed by the development, or
    c. other conditions or hazards exist that warrant analysis, as determined by the District.

II. Conditions Applicable to Structures

The placement of structures within floodplains represents placing lives and property at risk. Since Flow Corridors are areas of higher risk, every effort must be made to locate structures outside of Flow Corridors. When relocation is not an option, extra design considerations are warranted to ensure that construction accounts for current and foreseeable future conditions within the Flow Corridor.

A habitable structure is any structure that is used for purposes other than vehicle parking and limited storage. Habitable structures include site-built homes, manufactured homes, guest houses, studios, workshops, etc.

A. Requirements for Structures Within Flow Corridors

1. When the flow corridor is subject to braided or distributary flow, it must be assumed that flow conditions at the location of the proposed structure will change over time. Therefore flow depths and velocities at the site may increase. When determining the appropriate Base Flood Elevation (BFE) and erosion protection measures for a structure, the more restrictive of the following criteria shall be used unless an alternative is justified by an engineering analysis:
    a. a minimum BFE of at least 0.5 feet regardless of current flood conditions, or
    b. the most restrictive flow conditions (BFE and velocity) within 50 feet of any habitable structure and 25 feet of any non-habitable structure.
2. Any structure, including any fill pad associated with the structure, shall not be placed on existing or historic channels or flow paths unless an engineering report submitted to and approved by the District:
    a. demonstrates that the proposed location is the least hazardous location on the parcel, and
    b. provides a foundation design using the analysis criteria in I.C.

III. Fences and Walls

Fences and walls have the potential to significantly alter or obstruct flow, and are discouraged within Flow Corridors. Whenever fences/walls are proposed within a Flow Corridor, open type fences, as defined by Technical Policy TECH-005, are the preferred option.

Except as noted in this policy, fences and walls shall be constructed pursuant to the standards of Technical Policy TECH-005. Application of the requirements below is at the discretion of the District based upon site-specific conditions.

A. Open Fences

Open fences shall be constructed pursuant to the standards of Technical Policy 005.

B. Woven Wire and Wrought Iron Fences

The following additional criteria apply to woven wire fences within Flow Corridors:

1. In all cases, woven wire and wrought iron fences shall be elevated at or above the Base Flood Elevation, unless:
    a. the fence is less than 50% of the width of the property perpendicular to flow (property line setback requirements from Technical Policy TECH-005 still apply), and/or
    b. the fence encloses a small portion of the parcel for the purpose of:
        i. enclosing a swimming pool, or
        ii. providing a small enclosure for pets or personal use.
2. When spanning regulatory washes, woven wire fences must be elevated at or above the Regulatory Flood Elevation as measured at the top of the banks of the channel.
3. Individual strands of wire may be placed horizontally below the bottom of the fence at six inch intervals per Technical Policy 005.

C. Solid Fences and Walls

The following additional criteria apply to walls and solid fences within Flow Corridors.

1. Walls and non-elevated solid fences are prohibited, unless.
    a. the wall/fence is located entirely upon an approved fill pad, or

b. an engineering report prepared by an Arizona registered civil engineer demonstrates that wall/fence will not adversely impact any adjacent parcel under intact and failed conditions, or
c. the purpose of the wall/fence is to enclose a swimming pool and the wall/fence is;
    i. at least 50 feet from any property boundary, OR
    ii. located immediately upstream or downstream of the principle dwelling unit and,
    iii. located at least 25 feet from the upstream property boundary, and
    iv. the wall/fence does not create more than 25 feet of additional encroachment as measured perpendicular to the direction of flow.

2. In lieu of C.1.a through C.1.c above, solid fences may be elevated at or above the Regulatory Flood Elevation.
3. Individual strands of wire may be placed below the bottom of the fence/wall at six inch intervals per Technical Policy 005

IV. Access and Utilities

Since flows within Flow Corridors are expected to be both more frequent and more hazardous, use of Flow Corridors for property access increases the risk of harm and lack of access to/from the property by residents and emergency response personnel and is therefore discouraged.

Driveway/Roadway crossings within Flow Corridors may also create considerable maintenance and safety issues if not properly designed, constructed, and maintained. These problems include sediment-transport disruption, increased flow velocities and scour downstream of the crossing, ponding and flow diversion upstream of the crossing, unintended overtopping of the roadway due to debris clogging of culverts and erosion of channel banks adjoining the crossing. Crossings that utilize the natural main-channel depth, width, and slope at the crossing location will have the least impact and are therefore recommended.

Similarly, placement of utilities within Flow Corridors can present safety hazards, and improper design of utility crossings could lead to disruption of service and create additional safety hazards due to damage.

A. Access Crossings

The following standards apply to driveway and roadway crossings (hereafter, access crossings).

1. Access crossings are discouraged at locations where the watercourse is braided. Where braided watercourses must be crossed, crossings that minimize flow contraction and disruption of sediment balance are recommended.
    a. Unimproved access crossings are recommended.
    b. Improved access crossings shall be designed per Technical Policy 027.
2. Access crossings shall be designed so the roadway alignment is perpendicular to the watercourse in order to minimize disruption to the floodplain. Exceptions may be made due to site constraints such as easements, on a case by case basis.
3. Access crossings shall generally be located:
    a. at the narrowest part of the floodplain, or
    b. where there are the least number of braids to be crossed.
4. Approval of the access crossing or the development necessitating the crossing may be conditional upon inspection of the construction of the crossing during or after construction.

B. Utility Crossings

The following guidelines apply to utility crossings.

1. Utilities shall be buried below the total 100-year scour depth in the main channel(s), including any long-term scour component (i.e., streambed degradation), unless acceptable engineering mitigation is provided;

2. Where the potential for lateral migration of the main channel(s) exists, underground utilities shall be buried at the same elevation in the overbank areas or erosion-hazard area as in the main channel, unless controls are in place to prevent utility damage and/or exposure after lateral movement of the main channel;
3. When practical, utilities shall cross at the same location and in the same manner as access crossings, and be:
    a. located on the upstream side of the culvert or at-grade crossing unless placement at the downstream location is justified, or
    b. incorporated into the design of improved crossings;
4. After construction, utility crossings not associated with an access crossing shall be revegetated in a manner consistent with all applicable local, state, and federal laws and regulations. U.S. Army Corps of Engineers 404 Permit requirements typically provide guidance for this activity.
5. Utility crossings that are not co-located with access crossings shall generally be located:
    a. at the narrowest part of the floodplain, or
    b. where the least number of braids will be crossed.
6. Approval of the utility crossing or the development necessitating the crossing may be conditional upon inspection of the burial depth of the utilities and/or constructed development protecting the utilities. Inspections may be conducted by the District and/or other agencies.

V. Historical Flow Corridors and Corridor Equivalents

There are several Flow Corridors or equivalents that were established prior to this Policy with specific requirements that differ from this Policy. The treatment of each of these Flow Corridors and equivalents is established below. Any Flow Corridor not specifically referenced below is subject to the requirements above in full.

A. Black Wash Administrative Floodway

The Black Wash Administrative Floodway was established by Floodplain Study #15, *Black Wash Drainage Analysis and Policy Assessment Report*, dated 9/12/1990. As a result of this study, the Black Wash Administrative Floodway has been regulated under the floodway provisions of the Floodplain Management Ordinance. The Black Wash Administrative Floodway shall continue to be regulated in this manner.

B. Brawley Wash Corridor

The Brawley Wash Corridor was established by Floodplain Study #42, titled *Brawley Wash Primary Flood Corridor Study*, by Simons, Li & Associates dated 6/1/1999. By at least 9/27/2002, per a memorandum by Barbara L. Johnson, P.E., Manager, an engineering study was required for development within the Brawley Wash Primary Flood Corridor (hereafter Brawley Wash Corridor) established by Floodplain Study #42. This was preceded by a history of denying permits within the Brawley Wash that predated even the mapping of the Brawley Wash Corridor, according a memorandum from Director Antonio C. Paez dated 6/2/1995.

In practice, the engineering requirement within the Brawley Wash Corridor has only applied to the construction or placement of structures within the corridor. As such:

1. For the construction of structures, including the placement of manufactured homes, within the corridor, an engineering analysis shall be required that, at minimum,
    a. assesses the flood conditions on the property,
    b. determines the potential scour depth at the location of the proposed structure, and
    c. designs a foundation that protects the structure from erosion and scour.
2. For all other types of development, the provisions of this Policy shall apply to the Brawley Wash Corridor.

C. Lee Moore Wash Basin Management Study Flow Corridor

The Lee Moore Wash Flow Corridors were created by Floodplain Study #10 in 2009, which was an update of an earlier floodplain study for the Lee Moore Wash basin. The Flow Corridors established for the Lee Moore

Wash Basin were created largely to guide new commercial and multi-lot subdivision development. Subsequent restudy of the Lee Moore Wash watershed was completed in 2019. The 2019 study also delineated Flow Corridors. This report was not intended to guide single-lot development. As such:

1. For commercial and subdivision development the rules established by the 2009 report *Implementation Plan and Development Criteria for the Lee Moore Wash Basin Management Plan* shall apply. Namely,
    a. Flow Corridors are to be left in their natural condition, and
    b. Flow Corridors are to be left undeveloped and unimpeded.
2. For single-lot development, the provisions of this Policy shall apply to Flow Corridors using the 2018 and 2019 Flow Corridor delineations.

D. Tortolita Spine Wash

The Tortolita Fan Spine Washes were established by Floodplain Study #24, titled *Tortolita Area Basin Management Plan*, by Cella Barr Associates dated 8/3/1993. By at least 9/27/2002, per a memorandum by Barbara L. Johnson, P.E., Manager, an engineering study was required within these Spine Washes. In practice, the engineering requirement within Spine Washes has only applied to the construction or placement of structures within the Spine Washes. However, recent and more robust floodplain studies within the Tortolita Fan indicate that an engineering analysis isn't always warranted. As such:

1. For the construction of structures, including the placement of manufactured homes, within the mapped spine washes, staff shall determine whether an engineering analysis is required on a case-by-case basis. When required, the engineering analysis shall, at minimum,
    a. assess the flood conditions on the property,
    b. determine the potential scour depth at the location of the proposed structure, and
    c. design a foundation that protects the structure from erosion and scour.
2. When an engineering analysis is not required for structures, and for all other types of development, the provisions of this Policy shall apply to development within the Tortolita Spine Washes.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 5/18/21
Date(s) Revised: N/A

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT'S
TECHNICAL POLICY

POLICY NO: Technical Policy, TECH-033 **EFFECTIVE DATE:** August 1, 2013
REVISION DATE: 5/18/21

POLICY NAME: Criteria for Two-Dimensional Modeling

PURPOSE: To standardize Two-Dimensional Modeling for hydrologic and /or hydraulic studies in Pima County, Arizona.

BACKGROUND: Two-Dimensional (2-D) flood routing modeling is typically used in those areas where flows are distributary and/or non-uniform and where the terrain is too complex to be modeled accurately by one-dimensional models designed for riverine floodplains. The changes in flow patterns associated with such runoff make it necessary to utilize 2-D models that react both to the terrain and hydraulic fluctuations through the duration of the flood hydrograph. A 2-D model can include rainfall and/or runoff modeling. This policy outlines the Pima County Regional Flood Control District's (District) standards for 2-D model submittals.

POLICY:

Two-Dimensional (2-D) modeling reports submitted to the District for review shall adhere to the following procedures:

A. The report shall state the name, version and build number of the 2-D model used. Be aware some models and versions may not be considered a hydrologic and/or hydraulic numerical model meeting the minimum requirements to be acceptable for remapping a floodplain through the Federal Emergency Management Agency (FEMA). The 2-D model submitted to the District must be in a version the District is able to review.

B. Unless otherwise approved by the District, the 2-D model and subsequent map products shall contain digitally projected data with the following projection control:

- Projection: State Plane, Arizona Central Zone
- Horizontal Datum : NAD83-92(HARN)
- Units: International Feet
- Vertical Datum: NAVD-88

C. The digital elevation data shall be incorporated into the 2-D model using the following criteria:

1. The grid size must capture the detail required for the project, and digital elevation data must be adequate to support the selected grid resolution. The engineer shall provide justification for the size of the grid elements. It is recommended the engineer discuss the grid element size with the District before conducting the study.

2. Two dimensional models allow for flow to spread out across the Digital Elevation Model (DEM). Therefore it is often necessary to extend the limits of the DEM upstream and downstream from the project site to allow for the natural expansion and contraction of the flow through the duration of the hydrograph.

3. An electronic copy of the DEM in ASCII format is to be supplied to the District if the data does not come from an accessible public source. If from a public source, the source shall be identified in the report.

D. Hydrology can be modeled with some 2-D modeling software although the software may limit the type of hydrologic methods used. When using 2-D software to perform hydrologic modeling, the following criteria shall be followed:

1. Watershed delineation may be difficult due to the distributary nature of the terrain. The watershed delineation shall include all potential contributing drainage areas and locations of interest. In addition to the DEM, the use of aerial photography, including historical aerial photography is recommended to discern watershed boundaries. Preliminary models may be useful to determine the location of breakout flows from the contributing watershed.

2. Modeling criteria shall follow District *Technical Policies TECH-010, TECH-015 and TECH-018*.

3. The rainfall values are not to be aerially-reduced unless approved otherwise by the District.

4. In order to reduce the size of or otherwise limit the upstream modeling extent of the 2-D model, hydrologic modeling of portions of the watershed upstream of the project may be accomplished by methods presented in *Technical Policy TECH-018*, and the resulting flood hydrograph may be input into the 2-D model as inflow hydrographs. Rainfall shall be added to the model downstream of inflow hydrographs, unless the engineer justifies that adding rainfall will not have any significant impact to the total inundation maps or the total flow volume. The rainfall distribution shall be the same as the design storm used to produce the inflow hydrograph.

   The following criteria shall be applied to create rainfall distribution for cases where PC-Hydro is used to create the inflow hydrographs:

   a. When the watershed is less than one square mile, or results in a PC-Hydro time of concentration of less than one hour, the NOAA Atlas 14 Point Precipitation Values from the Upper 90% confidence limit values for the 5, 10, 15, 30 and 60 minute storms are to be used to create a rainfall distribution. These rainfall Intensity-Duration-Frequency (IDF) values are to be used with the peak intensity rainfall value centered in the Isohyetal graph for a total duration of one hour.

b. If other hydrological criteria are to be used other than that described above, the hydrological methodology is to be discussed with and approved by the District prior to report submittal.

5. Hydraulic modeling of 2-D models are to follow the following guidelines:

   a. Multiple runs may be necessary in dynamic distributary areas. Dynamic distributary areas are regions in which there is a greater chance of flow redistribution overtime. Dynamic distribution areas are subject to channel avulsion and sedimentation. Such areas may also be susceptible to debris changing the discharge distribution. Multiple floodplain models may be necessary to account for flow re-distribution. Multiple runs may include but are not necessarily limited to creating channel blockage (or levee) situations to force more flow into other paths, or increasing the discharge values along each flow path. The multiple runs are to be combined to create a map from the maximum depths, water surface elevations and flows. Careful examination of the site conditions, soils, historical aerial photography and hydraulic conditions are warranted prior to developing the flow variables. Consultation with District staff is recommended prior to mapping flows in active distributary areas.

   b. Hydraulic structures such as culverts, detention basins, levees, constructed channels or natural channels be modeled following the guidelines within the user's manual for the software program. The engineer is to provide a narrative description of the hydraulic structures modeled.

6. The output of a 2-D model is to include the following:

   a. The output data for the entire modeling domain, in the form of gridded shapefile or raster image is to include:

      i. Grid identification (#)
      ii. Ground elevation (ft. above mean sea level in the vertical datum currently used by the District)
      iii. Maximum flow depth (ft.)
      iv. Maximum water surface elevation (ft. above mean sea level)
      v. Maximum velocity (ft/s)

   b. Unique output data may be required depending on type of project. Such output data may include but is not necessarily limited to:

      i. Flow vectors (direction)
      ii. Duration of inundation (hrs.)
      iii. flow depth > 3 feet
      iv. Momentum computations such as
         1. velocity * depth (ft^2/s)
         2. velocity-squared * depth (ft^3/s^2)

c. If floodplain flow-recording cross sections are generated, the placement of the cross sections are to be perpendicular to the flow path as determined at the moment of maximum inundation. Output generated from the flow recording cross sections shall include:

   i. Cross Section identification number (#)
   ii. Peak discharge (cfs)
   iii. Total volume (acre-ft)
   iv. Hydrograph

d. When practicable, water surface contours generated from maximum water surface elevation data.

e. Floodplain inundation feature classes may be requested by the District. In order to generate a useful floodplain management tool, polygon shapefiles should have:

   i. Vertices reduced to simplify the data management stress on GIS platforms.
   ii. Smooth boundary limits to match the digital terrain and aerial photography.
   iii. Disconnected floodplain polygons reduced or eliminated.
   iv. Isolated non-inundation areas within the greater floodplain area reduced or eliminated.

f. The engineer shall include point or line shapefiles for the hydraulic structures.

7. Hydrologic and hydraulic work maps shall be prepared in conformance with *District Standard DS-305*.

8. The report is to include the digital 2-D model input and output data on disk, portable hard drive, or an FTP shared access website.

9. Technical guidance for hydrologic and hydraulic modeling utilizing the FLO-2D (V. 2009, Pro) software is provided as Attachment A.

APPROVED BY:

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Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Original Policy Approved: 8/1/13
Date(s) Revised: 5/18/2021